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A QUANTITATIVE AND STATISTICAL STUDY OF THE PLANKTON OF THE SAN JOAQUIN RIVER AND ITS TRIBUTARIES IN AND NEAR STOCKTON, CALIFORNIA, IN 1913

BY

WINFRED EMORY ALLEN

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INTRODUCTION

The biology of fresh water is an attractive field for investigation both from the standpoint of ecology and from that of its practical bearings on the problems of fisheries. The fresh water plankton with its varying components forms a biological complex, or association of both plant and animal forms which have an intimate relation not only each to the others, but also to the varying factors of their environment, such as light, temperature, organic and inorganic substances in solution, and to seasonal change attendant upon the run-off from the watershed.

The survey of San Francisco Bay undertaken by the United States Bureau of Fisheries in 1912-13 in coöperation with the University of California afforded an opportunity to initiate a survey of the plankton of the San Joaquin River, one of the principal tributaries of that bay. My position at Stockton as teacher of biology in the High School afforded some laboratory facilities and also a location near the head of tidewater where the ultimate contributions of the stream of the bay could be examined and where a variety of conditions were present, including both the main channel, and backwaters with varying rates of flow, as well as a canal much enriched by sewage.

The author is conscious not only of the serious and baffling difficulties that attend such an attempt at a continuous piece of work but also of the errors which inevitably creep in, especially in the initial stages of such an enterprise. These errors are, however, in the main, distributed throughout the data and do not necessarily invalidate our conclusions. Such errors as occur in taxonomy are due to lack of the specialist's knowledge of nomenclature and synonymy, and of his critical skill in the finer distinctions of species and subspecies. The species as I have recorded them are at least groups of recognizably similar organisms. The largest source of significant error in this ecological study is the not improbable inclusion in such groups, of small numbers of less abundant or rare species of closely similar form.

ACKNOWLEDGMENTS

This investigation owes its origin to the committee in charge of the survey of San Francisco Bay, of which Professor Charles A. Kofoid, is chairman, and was undertaken under the auspices of the United States Bureau of Fisheries, to which I am indebted for equipment of nets and supplies.

Both Dr. F. B. Sumner and Waldo K. Schmitt, successive naturalists of the United States Steamship "Albatross," have lent their encouragement to my efforts and have also titrated some water samples. For literature, or assistance in securing it, sincerest thanks are hereby given to Professor S. A. Forbes, of the Illinois State Laboratory of Natural History, to the Michigan State Fish Commission, to Professor H. W. Conn of Connecticut, to Professor H. B. Ward of the University of Illinois, to Dr. Vincente Izquierdo of Santiago, Chile, to the United States Geological Survey, to the Chief of Engineers of the United States War Department, to Professor F. E. Clements of the University of Minnesota, to Dr. William F. Allen of the University of Minnesota, and to the Library of the University of Minnesota, to Dr. C. Dwight Marsh of the United States Bureau of Plant Industry, to Mr. H. K. Harring of the United States Bureau of Standards, to Professor C. J. Elmore, Grand Island, Nebraska, to Dr. B. W. Evermann of the California Academy of Science, to Professor E. A. Birge of the University of Wisconsin, and to Professor C. A. Kofoid of the University of California.

Dr. Marsh and Mr. Harring have also very kindly made some identifications of copepods and rotifers. Very material aid has been given by Mr. E. P. Higby of the California State Hospital at Stockton, who has given full use of his weather records, and to Mr. Lawrence Backes of Stockton for photographic views of the stations. Above all it should be said that whatever value there may be in the present paper is largely dependent upon the advice, encouragement and assistance of Professor C. A. Kofoid; and upon the painstaking care with which Mrs. W. E. Allen has computed, recorded and preserved most of the data as they came to hand. Inasmuch as Professor Kofoid's report on the Illinois River has been in constant use for reference and guidance it has been used liberally for suggestive outline of discussion. Many of its generalizations and conclusions are assumed

as applying here, but some points will receive special notice for the purpose of comparing conditions there and here when the data will permit.*

GENERAL FEATURES OF THE SAN JOAQUIN RIVER BASIN

The writer has not yet had sufficient opportunity to collect detailed information on this topic. The California report by Clapp and Henshaw (1909), to the United States Geological Survey, upon the surface water supply gives an excellent discussion of the most important features and it forms the main basis for this present brief discussion.

GENERAL CHARACTERISTICS

Two points of difference from the typical river basin in its latitude are interesting characteristics of the San Joaquin. First, its drainage is northwestward away from the equator. Second, it consists throughout of a rather deep trough with comparatively abrupt sides and unusually flat bottom, the level of which is repeatedly broken by the deltas of tributaries entering in most cases very nearly at right angles. The land surface varies markedly in character with the differences in these tributaries, but with a constant tendency to the formation of swamps and marshes at the lower points through the deposit of the lighter organic matter not left in the tributary deltas. This condition is very prominent from some distance above Stockton on to the mouth of the river. Stockton itself is on the eastern border of an area of swampy peat land through which the course of the river can be maintained only by extensive systems of levees. Even then great stretches of the lower levels are inundated each year, and Stockton has the perennial problem of escaping from floods.

It is quite evident from the foregoing that the lower valley as a whole is fertile, with a deep soil of good texture. The lower part is fairly well settled but there is as yet no adequate control of the water supply and an extensive area is practically undeveloped. The few cities are small and far apart. None of them is so situated as to cause any appreciable contamination of the river water near Stockton. The whole basin is under the direct influence of the "dry" and "wet" seasons. With its low levels, this results in sluggish, almost stagnant flow of the main river during the first, and a brisk flow during the run-off of flood waters incident to the second.

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* This paper is published by permission of Dr. H. M. Smith, commissioner of the United States Bureau of Fisheries.

LOCATION

SIMILAR GEOGRAPHIC LOCALITIES

The San Joaquin River lies in about the same latitude as the larger part of the Mediterranean Sea, the headwaters of the Tigris and Euphrates, and a considerable portion of the Hoang Ho, both of headwaters and lower reaches. It extends northwest from about 35° to 38° N. latitude between 118° and 122° W. longitude. The main basin lies on the isotherm of 60° F. Similar average temperature conditions are found in the Potomac region of the United States, along the northern border of the Mediterranean Sea and in north central China near the coast. Stockton lies in latitude 37° 57′ 30″ N., longitude 121° 17′ 30″ W. and on isotherm 60° (15.5° C). The altitude at the steamer landing in mid-city is sixteen feet, according to Mr. A. L. Miner, assistant city engineer.

GEOGRAPHIC AREAS OF MIDDLE CALIFORNIA

The part of California containing the San Joaquin system is a region of great diversity, but it is quite distinctly composed of three parallel strips of country. There is the Coast Range at or near the western border of the state, the central plain known as the San Joaquin Valley, and the Sierra on the eastern border. The part with which we are immediately concerned is comprised in the eastern slopes of the Coast Range, 4,000 square miles, the valley, 12,700 square miles, and the western slopes of the Sierra, 16,000 square miles. The range of altitude is from near sea level in the lower valley through some hundreds and thousands of feet in the Coast Range and the Sierra foothills up to over 14,000 feet in the High Sierra. The gradient is slight lengthwise of the valley, very steep, commonly twenty to forty feet to a mile, to the Coast Range, and generally moderate to the Sierra, averaging nearly five feet to a mile.

SIZE AND FORM OF SAN JOAQUIN DRAINAGE AREA

The total length of the San Joaquin River is near 350 miles, 125 miles from the High Sierra to the main valley and 225 miles thence to the outlet into Suisun bay, 50 miles from San Francisco. All the important tributaries are from the Sierra slopes, which consist mainly of granites and metamorphic rocks, sedimentary and igneous. The slopes of the other side are mostly sandstone, shale and conglomerates.

The differences in gradient partly cause an asymmetery of the valley floor which is made prominent by the differences of the streams on the two sides. Since the streams on the east side are larger, they have built larger deltas with a wider spread as they cross the lighter, longer slopes. Deltas from the two sides have united across the valley, cutting off the Tulare basin. For this reason water from the large streams at the head of the valley does not reach the San Joaquin River, except in years of unusual rainfall. Thus about one-fourth of the main basin is practically separated from the rest and this southern area rarely has any influence on northern conditions.

FOREST AREAS

There is no important forest cover in the main valley. Some of the higher ground in the Coast Range bears shrubbery and light timber. The Sierra foothills are usually well covered with grass, brush and scattering trees. Above the foothills is heavy timber to 10,000 feet, above which none occurs. The famous Sequoias occur in this region. National forests occupy about 65 per cent of the Sierra slopes.

RAINFALL

The annual rainfall varies from five to twenty inches from south to north along the valley. The west slope has light rainfall with similar increase northwest. The Sierra slopes show heavier precipitation according to altitude, but with similar increase to northward.

IMPORTANT TRIBUTARIES OF SAN JOAQUIN DRAINAGE AREA

In addition to the foregoing consideration of the main river and the basin as a whole it is worth while to include some points concerning three or four of the principal tributaries which may have some recognizable influence at Stockton.

The Kings River

The King's River is the most southerly tributary that has any ordinary connection with the San Joaquin. Its relation is rather peculiar since its delta forms a large part of the barrier cutting off the Tulare Lake Basin from the main valley. This delta has been built in such a way as to carry the entire flow of the Kings River to the San Joaquin during low water, but most of the flood waters go to Tulare Lake. The altitude near the entrance of the San Joaquin is about 175 feet according to Clapp and Henshaw (1911).

King's River basin has fifty miles of Sierra divide as its eastern border, with some altitudes above 14,000 feet. Its length is about sixty miles in the mountains, with an area approximating 1,840 square miles. The river source consists of many little glacial lakes at the edge of glaciers and perpetual snow. The length of the river to the mouth of its cañon is nearly 85 miles.

The basin as a whole is very rough and irregular, the head especially including the most rugged region in the Sierra. Nearly all the tributaries run through glacial cañons cut through solid granite. Several of the latter are 2,000 or 3,000 feet deep. The whole formation is granitic.

The larger part of the basin is well forested up to 10,000 feet Most of it is in the National Forest Reserve. Precipitation ranges from eight to ten inches in the San Joaquin Valley to fifty or sixty inches in the high altitudes. Most of the precipitation of this basin is in the form of snow.

THE MERCED RIVER

The Merced River drains an area sixty-five miles in length from Mount Lyell on the Sierra divide (13,090 feet) down to the San Joaquin River. This includes a total of 1,200 square miles. The river itself is about 135 miles in length, with four or five tributaries of some importance, including the famous Yosemite Creek. Though the Yosemite Valley is the most remarkable, there are other parts of the basin very rough and broken, with many waterfalls and glaciated regions. About 850 square miles of the upper part of the basin is included in national forests, though there is little growth above 12,000 feet. The annual precipitation in the San Joaquin Valley near the mouth of the Merced sixty or seventy miles from Stockton, is ten to fifteen inches and it ranges through twenty-five inches in the foothills to about sixty inches near the divide Even in the mountains this precipitation occurs mainly in the rainy season, mostly as snow, the melting of which is most rapid in May and June.

THE TUOLUMNE RIVER

The Tuolumne River traverses a basin 105 miles long, two-thirds of which is in the mountains. The mountainous portion is about 1,680 square miles in area. This river is 150 miles long, about 80 miles of which is through a deep cañon cut down into solid granite. This cañon drains numerous glacial lakes at the Sierra divide, and the upland meadows slightly lower down. The basin as a whole is very rough, with bare, glaciated rocks of granite in the upper parts. Altitudes vary from 300 feet in the foothills to 12,000 or 13,000 feet at the divide. Upper parts have no forests, but there is a median belt heavily forested with coniferous trees. The lower region has only grass and brush, usually. There is about 1,200 square miles of National Forest in the mountains. Precipitation is about ten inches per annum in the region near the junction with the San Joaquin, 25 or 30 miles from Stockton. It ranges to sixty inches at high altitudes where most is snow, the greater part of which disappears in spring.

The Stanislaus River

The Stanislaus River has a long, narrow basin, about 75 miles in length and an area of somewhat over 950 square miles. The length of the river is about 120 miles, 80 miles in the mountains. The source is mainly in glacial lakes about the divide and the mouth is about 20 miles above Stockton. The general character of the basin is quite similar to that of the Tuolumne.

The Calaveras River

The Calaveras River flows near Stockton and empties six or seven miles below the city. It has some influence in flood season on account of the overflow, but in this case its influence would be much the same as that of those already mentioned since the flood waters of all are essentially similar. Furthermore, the flood waters of the Calaveras are largely kept from the San Joaquin above Stockton by an enormous levee forming the so-called "diverting canal."

TURBIDITY

The turbidity of the water of the San Joaquin in the vicinity of Stockton at all times of the year is very characteristic. In the river channel this is obviously due to fine silt during the flood season but the plankton is the principal source in the sluggish water of late fall. Water in some of the sloughs sometimes becomes clear enough to reveal objects at a depth of six or eight feet.

RIVER CONDITIONS NEAR STOCKTON

Relation of Stockton to Tidewater

In this connection it is doubtless worth while to reconsider the points already mentioned which have most obvious relation to Stockton conditions. First, we may emphasize the fact of the low gradient. Since the steamer landing at Stockton is only sixteen feet above sea level the water level must be only about eight feet above sea level for a considerable part of each year. Stockton is about one hundred miles from the Golden Gate, so the gradient to the sea is only about 0.08 foot to the mile. This must account in large measure for the range of the tide, which sometimes shows a difference of something over three feet between high and low water in Stockton Channel.

River Gradient Above Stockton

In the other direction, we find a rise to one hundred and seventy-five feet above sea level at the mouth of Kings River, probably about two hundred miles above Stockton. Assuming this distance as an approximation, we find the gradient above Stockton to average a little more than 0.8 foot to the mile. As might be expected from such a low gradient, there is a great deal of swamp land throughout the distance. Formerly there was annual flooding of this low area during the wet season, with a good deal of deposit of silt and stirring up of organic matter, much of which came from the death of plants and animals in the preceding dry season. The definite limitation and constant alternation of dry and wet seasons, together with the proximity of the mountains, must have had a very marked influence on plankton production in the low lands under such conditions.

OPPORTUNITIES FOR PLANKTON DEVELOPMENT

Recently more and more of these low lands have been reclaimed and protected by levees. The run-off is thus materially hastened in flood season and there is much less opportunity for plankton development than Kofoid has found for the Illinois River. There is also the further consideration that most cases in which impounding of the water occurs, show rapid evaporation after river subsidence, with great destruction of organisms before they have opportunity to get into the river channel. Unfortunately, definite information as to areas still open and details of their seasonal history are not available.

At any rate, it seems that one explanation of the apparent numerical deficiency in plankton production as compared with the Illinois may be that there is less impounded water ready to develop and discharge plankton, and that there are no frequently occurring minor floods to wash out these areas. It should be stated, however, that 1913 was an unusually dry year; hence the flood conditions were not typical for this region.

EFFECT OF THE MOUNTAINS

The mountains probably have just as much influence on plankton in the river as does the character of the bottom lands. The Coast Range has no very extensive influence. In the main it is rather against plankton production. The slopes are steep and the run-off torrential during the heavy rains. There are not many natural reservoirs such as either swamps or lakes, and the surface water is soon lost. Consequently very little plankton is contributed to the San Joaquin from these western tributaries. In fact most of them are dry through a large part of the year and the water they contribute in time of flood is so full of silt as to hamper rather than hinder plankton production in the main river.

TEMPERATURE

The Sierra Nevada seems to affect production in two rather important ways. First, temperature in their run-off is rather low for either quantity or variety of plankton in the higher areas during most of the year. On the other hand, there are few places for impounding the water in the lower areas and the streams move too rapidly for much development even on the comparatively low gradients of the foothills. Hence there is no very great contribution of plankton from any tributary. Second, the snows, glaciers, forests, lakes and swamps of the higher region all together constitute an enormous series of reservoirs which hold much of the water in check, not only greatly prolonging the flood season, but giving a remarkably even distribution of flood water over a period of weeks or even months. The effect of this is evidently twofold, inasmuch as the volume of water hastens the flow of the river and so may retard production, while at the same time it keeps many of the sloughs and swamps sufficiently filled to maintain a rapid plankton output. This period of flood from the Sierra often overlaps the period of floods in the valley due to the winter rains. In other cases it follows or is continuous with the same. Hence there are a few rises and subsidences of the floods, almost every year, some of which are effective in clearing out the sloughs and giving basis for a new plankton crop. The combined flood periods usually extend from late December to about July, after which there is gradual subsidence to the low-water conditions of sluggish flow and partial stagnation. It should be said that the term "flood" is here used to include all stages of water at Stockton which are high enough to keep a distinct current in the river.

The mean annual temperature of the valley, stated as 15.5° C, does not give a very good idea of the real conditions at Stockton. For one thing, the range in temperature in every twenty-four hours is considerable throughout the year. The nights are almost invariably cool even in late summer and by far the larger number of days become quite warm The average range for the year is about 8° C and is about 3° C in winter and 12° C in summer. On the other hand, the seasonal range is not so very great. Very rarely a high temperature near 40° C is reached in summer and a low temperature of about —10° C in winter. On the whole, there is good reason for thinking that temperature fluctuations in the San Joaquin River Basin have less influence than some other conditions on the general plankton production.

Light

Of course the fluctuations in available light are of great importance. These fluctuations are dependent on a number of conditions, such as the seasonal changes in length of days, turbidity of the water, cloudiness, and agitation by wind. All these influences are most adverse during the winter months, coincident with adverse temperature, so that it is almost impossible to prove which is most responsible for scarcity of plankton at that time.

As already stated, the turbidity of the waters in the Stockton region is very great and fairly constant. During the greater part of the first six months of the year this is evidently due mainly to very fine silt. During the rest of the year the high organic content seems to have some influence. Although the net with its brass parts was a rather conspicuous object in clear water, it was never visible one meter below the surface at any station. There are, however, no data available for accurate determination or comparison of turbidity.

Air Currents

Since Stockton is in a low region adjacent to extensive swamp areas and waterways, it is considerably affected by fog and clouds. The exclusion of light from this cause is quite important in the course of the year. Being located almost opposite the Golden Gate, this region is also under almost daily influence of distinct air currents. These are very frequently strong enough to make the water surface quite rough and there is scarcely a day that it is not made ripply for some hours. This also causes important loss of light throughout the year.

CHEMICAL CONDITIONS NOT STUDIED

No definite data are available as to the chemical composition of San Joaquin waters. Hence discussion of this important factor must be deferred.

TIDE

The ocean tide is very much in evidence at Stockton, but the available data are not adapted to satisfactory study. The extreme range is about three feet, but that does not occur very often. The only local records were those from a private tide-guage kept by Dixon Brothers Transportation Company. These records were made very irregularly in connection with the movement of their barges and cannot be used with much confidence in this discussion.

AQUATIC AND MARGINAL VEGETATION

No definite study has been made of the aquatic and marginal vegetation of this section. The ocasional dredging of all larger waterways has kept down such growths in the places most accessible locally. Hence the following list must be regarded as incomplete. It is certainly inadequate so far as the typical delta flora is concerned.

Chara sp. occurs abundantly in some of the ditches and narrow waterways. It has not been observed in the river or in the larger canals, possibly because of the dredging. Where found it furnishes extensive lodging places for myriads of microscopic animals and plants.

Duckweeds, probably *Lemna gibba* L. and *Lemna minor* L., are very conspicuous in the fall in quiet nooks and ditches.

Typha latifolia L. is very abundant in a few places and is frequently found in small groups along any water margins.

Alisma plantago L. is said to be common.

Sagittaria is common and three species at least occur in this region. Apparently *S. latifolia Willd* is most frequent, though *S. greggii* J. G. Smith, and *S. sanfordii* Greene are more characteristic of the locality.

Urtica holosericea Nutt. is very abundant on most undisturbed levees and water margins.

Jussiaea californica fills some quiet sloughs and canals with an almost impenetrable mass of stems.

Scirpus lacustris L., is by far the most conspicuous plant in the marshes and shallow waters from one end of the valley to the other.

Carex marcida Boott. covers large areas of ground where the soil remains saturated though not completely submerged through most of the year.

Anemopsis californica Hook. occurs in temporary marshes and is peculiar to the rainy season.

The most abundant willows are *Salix nigra* Marsh., *S. lasiolepis* Benth., and *S. fluviatilis* Nutt. Although abundant by natural propagation, they are frequently planted along the levees to help to hold the dirt in place.

Populus fremonti Wats. is common along the water courses, but not abundant.

Rumex salicifolius Wats. is conspicuous in marshy ground, especially in the heavy loam and peat soils. *R. occidentalis* Wats. and *R. Crispus* are also prominent.

Polygonum amphibium L. occurs in the ditches and narrow waterways. So far as observed, it furnishes remarkably good shelter for minute animals and plants.

Ranunculus aquatilis L. is exceedingly abundant in small areas at times, forming dense mats in shallow water.

Nasturtium officinalis is reported as common, but it has not been observed by the present writer.

THE COLLECTING STATIONS

Three collecting stations were used. Plate 20 Station I was located in Stockton Channel at the foot of Yosemite street. This is about one mile and three-quarters from the river; four hundred yards from Mormon Channel outlet and three-fourths of a mile from the steamer landing at the head of Stockton Channel. There was a good deal of sewage coming down this channel Mormon Channel was an open cesspool during most of the year. Hence this station seemed to be fairly typical for the study of organisms in dilute sewage.

Station II was in the river, from four hundred to eight hundred yards above Stockton Channel, and it represented as nearly natural river conditions as could be found in this section.

Station III was in Smith Canal about four hundred yards from the river. There was a small amount of sewage coming down this canal from the outskirts of the city. There was also a small slough about one hundred yards from the place of collecting. The general similarity to river conditions was well marked.

Station IV was not used in this series.

Stockton Channel and Smith Canal are more subject to disturbance by prevailing winds than is the river. Smith Canal being shallowest, Station III was probably most affected.

Stockton Channel was vastly more disturbed by river traffic than either of the other stations. Smith Canal was rarely affected in this way. Station II, in the river, was probably not stirred up one-tenth as much as Station I.

The turbidity of the water was least at Station III during 1913, and greatest at Station II. But Station III was never clear and the turbidity was not much less than at Station I.

Since the times of taking the temperatures at the various stations varied by an hour or more, an accurate comparison is impossible. The observer, however, always expected to find the highest temperatures at Station I, and the lowest at Station II and something between these at Station III.

There was no vegetation of consequence near Station I, but the levees were heavily covered at both the others. No aquatic vegetation occurs at any of the stations.

RIVER CURRENTS AND DEPTHS

Tidal currents were sometimes very noticeable at all the stations, but strong currents of any sort were very rare except at Station II, where they were noticeable for several months during the spring and early summer. The highest estimate placed on the rate of the river current in 1913 was four miles per hour. River transportation men, notably Captain Curry of the Island Transportation Company, say that five miles per hour is often reached during the heavier floods.

The least depth of water noted at the stations at low tide was about one and one-half meters at Station I, two and one-half meters at Station II and one meter at Station III.

COMPARISON OF STATIONS

The general form of the three channels is somewhat different. The bed in all cases seems to be a clay with variable superimposed ooze. Stockton Channel is a straight canal ending blindly at the steamer landing, two and one-fourth miles from the river. It is nearly the same width throughout, probably two hundred feet on the average.

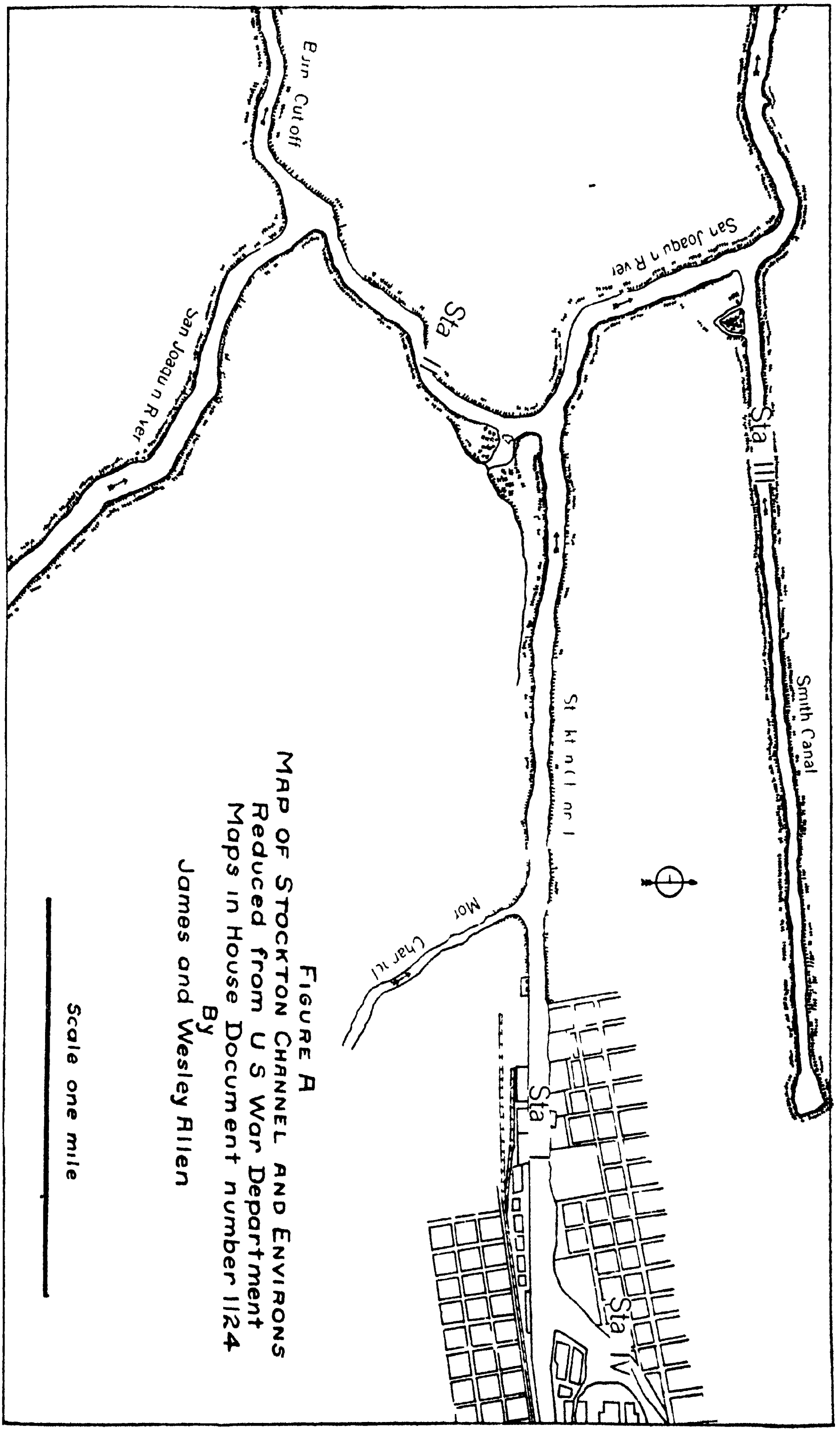

FIGURE A
MAP OF STOCKTON CHANNEL AND ENVIRONS
Reduced from U S War Department
Maps in House Document number 1124
By
James and Wesley Allen

Fig A

Its flow is westward. Mormon Channel empties into it about half way up on the south side. Miner Channel, after traversing the city as an open ditch, empties into it through McLeod's Lake about three hundred yards from the steamer landing. McLeod's Lake is merely a broad slough some four hundred yards in length. It was almost filled with arks and boat houses during 1913. All sorts of rubbish and refuse were dumped into Miner Channel and McLeod's Lake at that time, including some sewage from factory drains and some refuse from the tannery.

The river channel is very crooked. The general direction is northeast for about one mile above Station II. At Station II it is nearly east, but within another half mile it has turned to the west. The width is kept fairly uniform by dredging and it probably averages one hundred and twenty feet near the station.

Smith Canal is a straight channel about sixty feet wide and two miles long, ending abruptly at the northwest city limits. An open ditch across the northern edge of the city carried waste water from certain gas wells and some sewage directly into its upper end, during most of 1913. This ditch was also partly filled with rubbish and garbage.

METHODS OF SECURING DATA

TIME OF COLLECTING

Most of the collections at Stations II and III were taken at seven-day intervals, at week ends. There was occasional variation of a day or two. Collections at Station I were made twice a week. The midweek collection was usually on Wednesday. In a few cases there was a change of a day or two in the interval, but there was no failure to make two collections in any week.

One series of daily collections was taken in Stockton Channel for one month in July and August. Another series of hourly collections was taken for twelve hours in Smith Canal about one mile from the river. The plankton content was slightly different from that of the regular station in Smith Canal, but this was not realized at the time the series was being taken. The difference is not great enough to prevent instructive comparison.

The time of day at which collections were taken was very variable. Most of the midweek collections were taken after school in the late afternoon. Most of the week end collections at all stations were taken in the forenoon.

THE FORM OF NET

The first few collections in January were obtained with a temporary net made of used mill silk. But a net, of number 25 new bolting silk, was put into use on January 15, 1913, and was used continuously to January 1, 1915. There were occasional changes of drain cups.

The net was constructed after a plan suggested by Professor C. A. Kofoid. Outspread, its general form is that of a very broad and short truncated cone, the base having a total circumference of 166.65 centimeters and the apex 17.59 centimeters. The slant length is 60 centimeters. In order to avoid the awkwardness of such a shape, eight equal folds are made lengthwise and their upper edges closed. The inner points of the folds are then fastened directly to a brass ring of proper size. The outer points of the folds and an unfolded part between each two is bound by butcher's linen to a slightly conical brass plate with an opening in the middle which will pass just 10,000 cubic centimeters of water for each meter hauled, i.e., 100 square centimeters area. The convex surface of this subconical plate is kept outermost, so that in hauling the water may all pass away from the opening, except that which is in the column immediately before it.

A small brass cylinder is fitted into the small end of the net and fastened there by butcher's linen. Smooth grooves on the outer surface of the cylinder, near each end, serve for securing it to the net as well as for attaching the drain cup to the distal end.

This drain cup is made of the same silk as the net. It is a very simple pocket, about 5 centimeters deep, made of two semicircular pieces sewed together by the circular edges. The straight edges thus form the top of the cup, just large enough to slip over the end of the brass cylinder. The size was not kept quite uniform but the filtering surface of this cup averaged about 100 square centimeters in 1913. A draw string of white tape is run around the margin of the cup and fastened by a small hook and eye, such as is used by dressmakers. The draw string makes it possible to slip the cup over the cylinder end without tearing. The hook and eye, when properly adjusted, makes a very secure fastening, easily and quickly opened or closed.

The total net surface before shrinkage, was 5,527.20 square centimeters, not including the drain cup. The total filtration opening as calculated from micrometer measurements was 690.9 square centimeters. This gives a filtration outlet somewhat more than six times the area of the inlet to the net. Before using, the net was placed in warm, soapy water and gently rinsed in order to induce uniform shrinkage.

The drain cup was removed after each haul and the contents washed off into a small pail. Some organisms clung very tenaciously to the net and vessels. This was especially true of the stentors and some rotifers. The water in the pail was strained through a silk cup at the end of the collection.

THE AMOUNT OF HAUL

The standard collection covered an aggregate haul of twenty-five meters. Sometimes it was not possible to make a full collection. On a few occasions the light was too poor to make a full midweek collection. At these times it was usually possible to take half the usual haul. On still fewer occasions the silt clogged the net so badly in the river that only about one-fifth of a standard collection was taken. Even so it seemed that the net would surely break before it drained. Drainage of the net was always hastened by shaking the net slightly or by working it with the fingers.

Most hauls at Station I were at the depth of three meters; at Station II, four meters, and at Station III, two meters. Sometimes five meters could be taken at Station II. On the other hand there were times when only one meter could be taken at Station III. Most hauls in the river were taken while drifting. Most hauls in Stockton Channel and Smith Canal were taken while at anchor. Except on one occasion all hauls were made by the same person. The net was always hauled as nearly as possible at such a speed that it would just fail to throw water from its mouth as it broke the surface. This was about one-half meter per second. All hauls were as nearly vertical as possible. No particular effort was made to get in midstream at any time. In fact some collections were taken near the bank because of deeper water there. A few collections were taken from boat landings when the writer's motor boat was not in working order.

RECORDS

Records were kept of the temperature of air and water at each station. The air temperature was taken first and it was always taken in the shade without much motion. The water temperature was taken by holding the bulb from one to three inches below the surface of the water and reading while in that position. Temperature was forgotten once during the year and on a few occasions it was taken at some distance from the point of collection. This was usually when there was a high wind that made any appreciable variation improbable.

The condition of the tide was recorded when it could be detected. Dixon Brothers' *Tide Record* is of some value for comparison, but it is so fragmentary that it cannot be depended upon. Corrections for this locality from the United States *Tide Tables* are of some value.

Records were kept of cloudiness, rain, fog, wind, roughness of the water, etc., at the time collections were being taken.

The hour and minute of collection was regularly recorded, usually at beginning and end.

PRESERVATION OF MATERIALS

The collections were preserved in formalin in four-ounce, cork-stoppered bottles of the so-called vaselinetype. The formalin was not measured accurately, but it was intended to be from 6 to 10 per cent. The stronger solutions were used for the heavier collections. The formalin for one collection was forgotten until two days after it was taken, but so far as known that is the only serious error. The total number of collections during 1913 is 242. The year 1913 was very dry with very little flood water at any station. On the contrary, the water was unusually low much of the time. For this reason it would not show the local plankton range and distribution most typically. But there were some features strikingly similar to river conditions in other parts of the world, and it will make a good basis of comparison with 1914 which was a wet year.

TESTS OF SALINITY

In spite of the low water it is not at all probable that sea water ever had any influence here except in causing tides. Surface samples of San Joaquin River water were taken at Station II at about the twentieth of each month. These samples were titrated for chlorine content by the scientific staff of the U. S. S. "Albatross" and their report is presented herewith. It is given in parts of chlorine per 1000.

Jan. 19	0.0280	July 19	0.0800
Feb. 19	0.0745	Aug. 21	0.0964
Mar. 29	0.1025	Sept. 21	0.1764
Apr. 26	0.1680	Oct. 19	0.2352
May 24	0.0032	Nov. 22	0.6600
June 21	0.0072	Dec. 20	0.1404

The most probable explanation of the variation shown is that the incoming tide carried some of the polluted Stockton Channel water up stream when the natural stream flow was very weak. No other tests of the chemical composition of water at any station are available.

MEASUREMENT OF VOLUME

In order to measure the mass of material secured in the collections, a Bausch and Lomb hand centrifuge was used. The sedimentation tubes were graduated to tenths of a cubic centimeter. This machine makes 23 revolutions to each turn of the crank. After a few trials it was decided to run at 54 turns per minute. While no amount of practice made uniform speed possible, the average was kept at about 1300 revolutions per minute. The time of running was four minutes. Experience indicated that this was a little longer time than necessary, but it was undertaken with the intention of compensating for any possible inaccuracy due to variation in rate. Since this indicated only the mass of material held by the net, it was necessary to make some supplementary test to determine as nearly as possible what volume went through. Only two or three such tests were made because of the pressure of other duties, but the indication from filter paper tests is that the net sometimes retains only one-tenth of the mass of material actually present in the water. This material is often composed principally of silt.

THE ENUMERATION

After considerable experiment, the count of the organisms in the catches was begun in September, 1914. Since the time available was nearly always at night, almost all the counting was done by artificial light from an ordinary 60-watt, frosted, incandescent globe. Only rarely was it possible to make two counts in one day. Hence the enumeration was not finished until the night of June 18, 1915.

APPARATUS

The microscope used throughout was a Spencer with 16 millimeter objective and 8x ocular. It was equipped with a quick screw substage and a Spencer mechanical stage. The Whipple ocular micrometer and the Rafter counting cell were used. Its largest square covered 1.1 square millimeters with the above lens equipment, so that the labor of calculating was slightly increased by the fractional area.

PROCEDURE

STANDARD CONCENTRATION

In preparation for counting, all catches were first brought to a volume of 100 cubic centimeters by addition of water or, in a few cases, by decanting some fluid. If the concentration was too great at this volume, dilution was made to 400 or 800 or 1,600 cubic centimeters. No other quantities were used because the increase in difficulty of computation would offset the difficulty in counting. This was due to the fact that the above quantities were used often enough to make the formation of computing tables useful for them.

METHOD OF FILLING SEDGWICK-RAFTER CELL

In the process of filling the cell after thorough mixing a little more than 1 cubic centimeter was taken quickly into a pipette. The cell was then filled as rapidly as possible until the cover slipped into place. This never occurred completely until there was a slight excess of fluid. The excess was immediately taken back into the pipette, leaving the cover glass flat. The possibility of some error is evident, but experiment indicated that this method gave more even distribution in the cell than any other and that errors were not appreciably more frequent than those attending other methods. The method was followed throughout the whole series and every detail was handled by the writer, so that there must have been practical uniformity. This would certainly reduce the significance of any error which may have been incident to the method.

MAKING AND RECORDING THE COUNT

After filling the cell satisfactorily, a rapid survey was always taken in order to estimate the relative amounts of plankton and nonplankton. The estimate was then recorded in percentage of silt. With these preliminaries completed, the work of counting was begun, fifty fields being always counted. This made a total of 60.5 cubic millimeters. Counting was begun on the proximal side of the slide at point 32 on the lateral scale of the mechanical stage. The field next to the wall of the cell was not counted, but the next five were taken consecutively. This process was repeated at point 16, then at point 80 on the proximodistal scale at the right end of the cell, followed by point 87. Points 16 and 32 distal, 87 and 80 left, were then taken in order. The detail count was completed by ten fields from point 15 to

27 in the median line of the cell. The whole count was completed by running over exactly half of the cell looking for strays and for a check on larger organisms which might be irregular in distribution. After a year's experience the writer is inclined to think that twenty-five or thirty fields would be sufficient for the detailed count in view of the half-slide check. At any rate he is satisfied that the possibility of error in counting will rest elsewhere than on the method of selecting areas for counting. It might be said too, that the year's experience indicates that the method of filling the cell gives as uniform distribution of plankton in the cell as can be hoped for in any case.

The method of recording the count was almost uniform. Mrs. Allen sat near the microscope and wrote down names or made check marks as the names were called. In two or three cases about half the catch was recorded by the writer while himself counting. On about ten occasions he recorded as much as ten fields in like manner. These were the only exceptions. Occasionally the writer called the name of one planktont when another was intended, the mistake being noticed because it did not sound right. It is altogether probable that some such mistakes were made which were not noticed. In addition to this, of course, we must recognize the presence of clerical errors not humanly avoidable in such a mass of material. It can only be said that all reasonable precaution has been taken to avoid them.

COMPUTATION AND TABULATION

After recording, the counts were computed for a full cubic meter, and then tabulated by key sheets, such as suggested by Professor Kofoid in his Illinois report. From these sheets they were finally transferred to the statistical tables.

IDENTIFICATION OF FORMS

Identification of species, or even genera, was very difficult in many cases. This was due to several conditions. First, the preserved planktont was often very different in appearance from the living specimen. Second, many kinds had very marked tendency to coherence or agglutination in formaldehyde. Third, many of the smaller organisms were hidden wholly or in part by silt or by larger organisms. Fourth, many different organisms have the same appearance in very young stages; they also resemble mature stages of simpler forms. Fifth, distinctive characters were frequently invisible in the position found in the Rafter cell. Sixth, many forms were not sufficiently figured and described in the literature immediately available for use. Seventh, much of the accurate identification of plankton forms would require long time and careful work, even for specialists in the various groups. The writer was hampered by lack of time and experience in identification in all groups. Eighth, the synonymy is confusing. This, however, is rather an aggravation than a difficulty in the sense of the foregoing.

This list certainly seems imposing as stated. As against it, the following facts should be noted. First, that more than one year was spent in studying the living materials, with both 16 millimeter and 4 millimeter objectives, before there was any attempt to count. In this way, sufficient familiarity was obtained with many forms to enable identification even in much contracted, distorted and broken conditions. Second, that most of the names as finally applied meant something definite to the writer, even though there might be error in their specific application. While this fact is unfortunate for the specialist who may wish to know exactly what species are present, it surely leaves the possibility of drawing some valuable conclusions as to seasonal changes, plankton rhythms, and relative numbers. Third, there were enough prominent planktonts, easy to identify, to make a good foundation for a report on plankton characteristics of this region at such stations as were selected. Fourth, those planktonts hardest to identify were mostly of the kind which would be largely lost through the meshes of the net, or which were adventitious and so of minor importance in solution of the greater problems of plankton production and distribution. Fifth, the various totals are not much affected by specific errors of identification.

ESTIMATION OF SILT

In estimating the percentage of silt, the same possibility of error was noticed as that mentioned by Kofoid (1908), i.e., some of the material, being flocculent in character, would appear unduly prominent in the Rafter cell; whereas, the compression of the centrifuge would make it relatively small in the volumetric record. While it seems probable that differences in the stations and in seasonal conditions give this error some real importance, there appears to be no way of avoiding it. There may be some compensation in the fact that with larger quantities of sediment there is usually a larger proportion of heavy materials, thus making the compressible materials less conspicuous.

The Clogging of the Net

The clogging of the net is undoubtedly an important factor affecting the catch and it was also quite variable under 1913 conditions here. Hence some designation of its probable condition is very desirable. In spite of this it was finally decided to ignore it for 1913 at least. This is because too few filter paper, or other supplementary, catches have been made to give adequate ground for estimation.

VOLUMETRIC DATA

There is not a great deal to say on this topic as yet. The main points are distinctly shown by plate 1 and table 6. The two most interesting points, in the light of such investigations elsewhere, are that only Station I shows a very distinct vernal pulse and that the autumnal pulses are most prominent at all stations. This statement needs some qualification since there was a higher maximum shown at Station I in March than in the fall. This vernal pulse was, however, so very abruptly developed, and the autumnal so very gradually, that it seems natural to assign the greater importance to the latter. At neither of the other stations does the vernal pulse compare in magnitude with the autumnal. Indeed, at Station III, there is no well marked, vernal pulse.

It is worthy of note that volumes appear least variable at Station I and most so at Station II. It might, at first thought, seem that this was owing to the uniformity of food supply at Station I, caused by the constant inflow of sewage throughout the year. Closer examination of the records suggests, however, that variation in speed of currents in the river, together with the dilution due to flood waters is more potent. This estimate of the importance of the current as a factor is supported by collections made in the San Joaquin River near Fresno, California, in August, 1916. Although this was the season for maximum occurrence of plankton at Stockton, not enough was taken by the net at Fresno to be measurable volumetrically with any accuracy. Since the current at Fresno is about as rapid in the dry season as at Stockton in flood season, it seems certain that it has a profound influence. Still the importance of the uniform food supply at Station I must not be minimized.

The whole series of collections for 1913 is now (1916) in the permanent possession of the Department of Zoology of the University of California.

ORGANISMS FOUND IN SAN JOAQUIN PLANKTON

Definitions

Professor Kofoid's definitions are followed as closely as possible, although only a few terms will be used. This report designates only three types of planktons, i.e., the continuous, the periodic and the adventitious. No closer distinction is advisable in view of the writer's lack of definite knowledge of life histories of various species. There has been no difficulty about the application of the general term "plankton" to the typically mixed population of minute living things found in these collections, because there was no case observed in which the plant or animal seemed distinctly out of place. It might be rare, and perhaps evidently ill-fitting, but in no way could its presence be regarded as surprising. Hence it becomes perfectly natural to apply the term collectively to all the organisms found.

Component Forms

A total of 471 planktonts was listed during the year, though only 396 were recorded from the preserved material. The number of species present was doubtless much greater. Those not recorded were found only in the living material and in small numbers. Of those recorded, some forms which might be distinct species were placed together in one because they could not be distinguished during the count. This lack of distinction was sometimes due to the inadequate preservation or to the rarity or to the difficulty of identifying specific characters while counting. Others were placed together because the writer's acquaintance with them was not sufficient for definite recognition. Very many were simply referred to the genus without attempt at species segregation because identification was too difficult to be undertaken in the time available. The question of probability of proper identification will be taken up in the detailed discussion of each form.

THE PRINCIPAL TYPES OF FRESH WATER PLANKTON

Among the 396 forms recorded and counted in the preserved material, 201 were thought to be positively identified as to genus, of which number 107 were also satisfactory as to species. The generic designation of most of the remaining 195 forms was regarded as probably correct though some were merely referred to the nearest possible genus or species according to the information at hand. The following table gives the general distribution of these forms among the three stations.

	At three stations	At two stations	At one station
Algae	90	29	53
Protozoa	56	26	37
Rotifera	44	11	26
Crustacea	8	2	2
Miscellaneous	3	1	8
Total	201	69	126

As might be expected of those found at only two stations most are from stations I and II. Those found at only one station are of the rarer, less conspicuous kinds.

This table shows the main characteristics mentioned by Kofoid (1908) as distinguishing fresh water from marine plankton. It may be well to enumerate his main points as verified in the present study. The plankton consists of cryptogams and invertebrates, with some orders missing and the others very variable in numbers of representatives. Larval forms are very few and the number of invertebrate groups much less than that of the sea. The small size of organisms in fresh water is also a conspicuous feature. There are no large crustaceans, no coelenterates, no mature mollusks, few worms, no tunicates or radiolarians, to make diversity such as that of the sea. In spite of the smaller size of the organisms in fresh water their total mass is much greater than that in the sea. The highest amount recorded here is 18 cubic centimeters per cubic meter; the smallest 0.28 cubic centimeters per cubic meter; while a typical marine product is stated as 0.12 to 0.48 cubic centimeter per cubic meter. The San Joaquin production noted was taken from net hauls only, the maximum from Stockton Channel, the minimum from Smith Canal. Filter paper catches show ten times the recorded volume in some cases.

MAJOR GROUPS OF PLANKTON

ALGAE

No plants higher than the algae have been found in these collections. Very few bacteriaceae were found because of their small size. Very few schizophyceae were conspicuous in 1913, though the numbers of individuals were sometimes large and the total quantity sufficient in late summer to give characteristic color to the waters. Bacillariaceae were always present and usually in large numbers. Many of them are doubtless adventitious. Chlorophyceae were not prominent, though some were present throughout the year. The conjugatae were not represented by many species and the numbers were few.

ZOOPLANKTON

Almost all the zooplanktonts found were included in the three groups Protozoa, Rotifera and Entomostraca. Other types of animals are decidedly rare.

Amongst the Protozoa, Ciliata and Mastigophora predominate. The group Mastigophora is meant to include the same organisms as comprised under that head by Kofoid (1908), i.e., "all green and brown flagellates, sometimes classified with the Chlorophyceae and Phaeophyceae." Rhizopoda were usually present but in small numbers. Heliozoa were rare except for one or two smaller forms which kept up rather large totals for the group. Suctoria were rare. No Sporozoa were recognized. Ciliata were distinctly more noticeable in the dilute sewage of Stockton Channel than at either of the other stations.

The Rotifera were even more prominent inhabitants of Stockton Channel than the ciliate Protozoa, but their numerical superiority may have been due to larger size and consequent capture by the net. The numerical difference at the other stations was not very marked. There is no question that their considerable size and large numbers entitle them to the leading place among analytic organisms assigned by Kofoid (1908) to the Illinois Rotifera. The greater abundance in the sewage laden water is, however, rather against his suggestion that they may be found to be more characteristic of river than of lake plankton. Local conditions indicate sewage or at least organic content as being a deciding factor. Apparently, most of the species recorded here are to be regarded as normal constituents of the local plankton.

With the exception of three or four specimens of *Gammarus* found on two different dates, and of a few miscellaneous forms, the Entomostraca are far the largest of the local planktonts. While much less numerous on the whole than they were in the Illinois River, they undoubtedly play a large part in the life of our waters. Copepoda, through larval forms, are distinctly in the ascendant, with Cladocera somewhat scattering and Ostracoda barely represented. Most of the forms found appear to be true planktonts. In fact, *Cypris,* the sole member of the Ostracoda, is the only genus which is evidently adventitious.

Turbellaria, Oligochaeta, Hexapoda, Hydrachnida, Gastrotricha and Bryozoa barely find representation at any station. Their influence in the plankton is negligible.

TOTALS OF MAJOR GROUPS

The following table of averages (text table I) will serve to indicate in some measure the proportionate representation in the San Joaquin plankton of the most typical constituent groups. As already noted elsewhere, 1913, was a comparatively dry year so that the production in most cases was probably below normal. The figures given are the result of the count of individuals, except in the case of colonial forms such as *Bacillaria, Synura* and *Scenedesmus* where the colonies only were counted. The small numbers as compared with Kofoid's similar table (1908) for the Illinois plankton of 1898 is mainly due to the fact that all San Joaquin enumerations are from silk net collections, whereas many of his were from filter paper catches. Our table includes all recorded forms whether satisfactorily identified or not. It should be noted that in the total of synthetic organisms Schizophyceae are included because they do some of that work. All of the Mastigophora are also included because there was not sufficient acquaintance with them to distinguish synthetic and analytic forms and it was understood that most of them found here were synthetic. The averages are computed on the basis of 104 catches for Station I, 52 for Station II and 51 for Station III. The daily and hourly series are not included in the general discussion except as incidentally referred to. They require separate discussion.

TEXT TABLE 1.—TOTAL PLANKTONTS BY MAJOR GROUPS

	Number of forms	Station I		Number of forms	Station II	
		Total	Average		Total	Average
Total Phytoplanktonts	85	2,720,856,600	26,162,100	97	2,216,347,628	42,622,068
Bacteriaceae	2	1,696,364	16,310	1	1,035,072	19,905
Schizophyceae	15	166,755,148	1,603,414	18	67,219,364	1,292,680
Chlorophyceae	15	188,417,098	1,811,722	13	77,972,944	1,499,479
Bacillariaceae	47	2,351,342,460	22,609,062	59	2,052,872,514	39,478,317
Conjugatae	6	12,651,930	121,653	9	17,247,734	331,687
Total Zooplanktonts	141	1,102,116,740	10,597,272	110	229,332 166	4,410,230
Mastigophora	25	385,691,226	3,708,569	20	136,713,846	2,629,112
Rhizopoda	13	17,402,198	167,328	9	7,842,488	150,817
Heliozoa	5	38,583,488	370,995	5	13,376,096	257,232
Ciliata	29	98,463,242	946,762	16	23,291,268	447,909
Suctoria	3	79,296	762	3	467,776	8,995
Total Protozoa	75	540,219,450	5,194,416	53	181,691,474	3,494,065
Rhizota	2	156,992	1,509	3	1,933,424	37,181
Bdelloida	6	36,328,460	349,312	6	2,449,472	47,105
Ploima	47	467,115,946	4,491,499	34	41,559,652	799,224
Total Rotifera	55	503,601,398	4,842,320	43	45,942,548	883,510
Cladocera	3	400,992	3,855	4	384,000	7,384
Copepoda	4	57,856,500	556,312	3	770,768	14,822
Total Entomostraca	7	58,257,492	560,167	7	1,154,768	22,206
Miscellaneous	4	38,400	369	7	543,376	10,449
Total planktonts enumerated	226	3,822,973,340	36,759,372	207	2,445,679,794	47,032,298
Synthetic		3,104,857,862	29,854,420		2,352,026,402	45,231,275
Analytic		718,115,478	6,904,952		93,653,392	1,801,023

TEXT TABLE 1 —TOTAL PLANKTONTS BY MAJOR GROUPS—*Continued*

	Number of forms	Station III		Number of forms	Daily	
		Total	Average		Total	Average
Total Phytoplanktonts	93	2,090,812,294	40,996,318	53	1,018,801,028	32,864,549
Bacteriaceae	1	116,992	2,294	1	115,392	3,722
Schizophyceae	16	99,840,742	1,957,661	12	80,574,044	2,599,163
Chlorophyceae	13	91,241,112	1,789,041	11	67,560,712	2,179,378
Bacillariaceae	55	1,878,169,822	36,826,859	25	869,719,232	28,055,459
Conjugatae	8	21,443,626	420,463	4	831,648	26,827
Total Zooplanktonts	108	253,153,822	4,963,800	61	335,441,120	10,820,681
Mastigophora	25	134,216,822	2,631,702	14	57,456,320	1,853,429
Rhizopoda	11	14,706,624	288,365	4	3,155,872	101,802
Heliozoa	4	14,003,600	274,580	2	19,193,826	619,156
Ciliata	17	22,003,692	431,445	6	40,488,334	1,306,075
Suctoria	2	409,984	8,039	0		
Total Protozoa	59	185,340,722	3,634,131	26	120,294,352	3,880,462
Rhizota	3	1,539,424	30,185			
Bdelloida	3	2,897,100	56,806	3	3,745,752	120,831
Ploima	33	61,996,492	1,215,618	27	165,007,160	5,322,812
Total Rotifera	39	66,433,016	1,302,609	30	168,752,912	5,443,643
Cladocera	3	469,040	9,197	2	230.400	7,432
Copepoda	3	742,032	14,549	2	46,141,056	1,488,421
Malacostraca	1	20				
Total Entomostraca	7	1,211,092	23,746	4	46,371,456	1,495,853
Miscellaneous	3	168,992	3,314	1	22,400	723
Total Planktonts enumerated	201	2,343,966,116	45,960,118	114	1,354,242,148	43,685,230
Synthetic		2,225,029,116	43,628,020		1,076,257,348	34,717,978
Analytic		118,937,000	2,332,098		277,984,800	8,967,252

TEXT TABLE 1.—TOTAL PLANKTONTS BY MAJOR GROUPS—*Concluded*

	Number of forms	Hourly	
		Total	Average
Total Phytoplanktonts	61	476,644,270	32,172,832
Bacteriaceae	1	112,192	8,630
Schizophyceae	12	64,886,064	499,123
Chlorophyceae	10	22,150,470	1,703,883
Bacillariaceae	32	377,380,220	29,029,248
Conjugatae	6	12,115,324	931,948
Total Zooplanktonts	72	179,588,061	13,814,465
Mastigophora	15	51,114,592	3,931,892
Rhizopoda	8	5,160,360	396,950
Heliozoa	4	5,739,216	441,478
Ciliata	6	40,775,578	3,136,583
Suctoria	1	25,600	1,969
Total Protozoa	34	102,815,346	7,908,872
Rhizota	3	209,888	16,145
Bdelloida	2	2,930,384	225,414
Ploima	29	70,717,563	5,439,813
Total Rotifera	34	73,857,835	5,681,372
Cladocera	2	451,776	34,752
Copepoda	2	2,463,104	189,469
Total Entomostraca	4	2,914,880	224,221
Miscellaneous			
Total Planktonts enumerated	133	656,232,331	45,987,297
Synthetic		527,758,862	36,104,724
Analytic		128,473,469	9,882,573

COMPARISON WITH ILLINOIS FORMS

As in the case of the Illinois River, this table shows plants to be more numerous than animals, though they are generally smaller. The disparity in numbers is slightly different being, in recorded order of stations 2.5, 9, and 9 to 1, instead of 5 to 1 as in the Illinois River The preponderance of Rotifera and Protozoa over Entomostraca is less marked than in Illinois, being 8.5, 45, and 50 to 1; and 9, 180, and 151 to 1, respectively. The numbers of Rotifera and Protozoa are not markedly different from each other in Stockton Channel though Protozoa are four or five times as numerous as Rotifera at the other two stations. In Stockton Channel synthetic organisms are relatively few even among plants proper. In this place the principal food of the zooplankton, therefore, is probably furnished by the Bacteriaceae and other saprophytic plants. For this reason the forms of plankton usually rated as important in more or less direct support of a fish fauna are few in kinds if not in numbers, although there is a conspicuous animal population.

At Station I, Copepoda (including immature forms) outnumber Cladocera about 18 to 1, but only about 2 to 1 at Station II and 1.5 to 1 at Station III. Protozoa are 1210, 500, and 404 to 1 of the Cladocera, distributed as follows: Rhizopods 45, 22, and 32 to 1, Ciliata 236, 64, and 48 to 1, Mastigophora 927, 361, and 292 to 1. Cladocera are outnumbered by plants 6540, 6090, and 4555 to 1. Diatoms are responsible for most of this with 5652, 5640, and 2314 to 1. Schizophyceae appear at 400, 185, and 217 to 1 and Chlorophyceae 452, 214, and 198 to 1.

The most striking features of these results when compared with those of Kofoid (1908) are two in number. First, there is the remarkable number of Copepoda in Station I. Second, the astonishingly small number of synthetic organisms and of Protozoa at all stations, in proportion to the number of Cladocera. Since Cladocera are almost all caught in the adult stage and since they are almost all retained by the silk net, they present very good ground for comparison of plankton catches everywhere. Hence the numbers of Cladocera, the lack in numbers of other organisms and the results of the few, filter paper catches point conclusively to the fact that the numerical and volumetric study of plankton calls for absolute filtration, high magnification and a laborious technique adequately to represent the sources of food, and the interrelations of the organisms of the plankton.

DETAILED DISCUSSION OF STATISTICS RECORDED BY THE AUTHOR

Prefatory

Tables and plates have been prepared to show in numerical or graphic form the various facts of distribution and occurrence which are or may be reckoned as important. This commentary is intended to elucidate and amplify such records and to serve especially as a guide to the details of observation or conclusion concerning which the writer is certain or uncertain. Averages, when given for each organism in numbers per cubic meter will be given for each station on the basis of 104 collections at Station I, 52 at Station II and 51 at Station III. Averages are only used because there is no other way of making a general numerical comparison in brief form. Temperatures, in degree Centigrade, are given both for surface water and for air. While the latter may be unnecessary it was thought that it might help to give an idea of the conditions locally.

Numbers of planktonts are recorded in units for the same reasons of consistency and convenience as those mentioned by Kofoid (1908). There is not the slightest intention to imply fictitious accuracy by unit expression. Those who prefer can read the record in "round numbers." The writer himself rarely gives any thought to more than the first three figures of a number.

ALGAE

Bacteriaceae

Members of this group were unquestionably abundant both in numbers and kinds, but they were very rarely retained by the silk net. In fact, *Spirillum undula* was the only representative recorded from Stockton Channel, the station most favorable for Bacteria and giving most evidence of their presence. The average number there, 16,310, is ridiculously small in view of the general conditions and in consideration of the filter paper collections which indicated a total volume of catch about ten times as great as that found in the silk net catches. The relatively great numbers of Cladocera and Copepoda also serve to emphasize the fact that the large portion of the plankton population is very freqently beyond the reach of the usual methods of observation. Silk net methods can never be more than suggestive of the productivity of the waters since they must deal mainly with the giants of the plankton. For that reason, an extended discussion of the Bacteriaceae cannot be undertaken for this series. It might be said, however, that general conditions indicate a maximum production of Bacteria in late summer along with the other groups.

Beggiatoa and *Micrococcus* were only recorded from Stations II and III, and then only once, but they were probably common at all stations.

Schizophyceae

	Station I	Station II	Station III	Daily	Hourly
Number of forms	18	15	15	15	7
Average per cubic meter	1,603,414	1,292,680	1,957,661	2,599,163	499,123

This group was most conspicuous at all stations in July, August and September, when it gave a peculiar color and appearance to the water, but it had some representation throughout the year. *Anabaena, Nostoc* and *Oscillatoria* were generally most prominent. Some of the smaller forms were probably represented but not identified. Some small forms were also probably confused with other groups. The group, as a whole, does not seem according to record to be of quite so great importance as in the Illinois, but this apparent lack is doubtless due to escape through the net. The color of the water alone would suggest that much of the material is lost. It is then, not only safe to say that the group is valuable in furnishing food for other organisms, but also that it probably holds a high place in working up the organic content of the water. Identification, even of genera, was frequently rather difficult in this group, although there was not often any question as to their belonging to the Schizophyceae. Names as recorded are to be regarded as suggestive rather than positive. Eyferth's *Einfachste Lebensformen* and Tilden's *Minnesota Algae* were the guides mainly used.

DISCUSSION OF SPECIES

Anabaena spp.

	Station I	Station II	Station III	Daily	Hourly
Average	57,600	317,644	437,967	245,139	1,531,949

Not clearly distinguished from *Nostoc,* straight filaments being the characteristic usually considered indicative. Includes some *Aphanizomenon.* Found occasionally throughout the year. Abundant only in July, August and September, at all stations, in a water temperature ranging from 23.5° C. to 28° C. Largest number recorded at Station I on July 12, Station II on August 9, and Station III on July 19.

Aphanocapsa spp.

	Station I	Station II	Station III	Daily	Hourly
Average	117,381	84,916	74,329	441,469	187,647

Most of the colonies counted under this name probably belong under *Clathrocystis* and *Microcystis.* There were probably few, if any *Aphanocapsa* present. The characteristics of *Aphanocapsa* were not understood until the count had gone too far for revision. Since *Clathrocystis* and *Microcystis* were also more or less subject to confusion it was thought best to let the record for 1913 stand under this head. The maximum production occurs at about the same time as that of *Microcystis* at all stations. Hence the error probably affects nothing but the question of species distribution. *Clathrocystis* does not appear on the record though now known to be present and it might be well to transfer the *Aphanocapsa* count to that heading. The late summer maximum, occurring in higher temperatures and the sudden fall in numbers in colder waters suggests the characteristics of *Clathrocystis* as noted by Kofoid (1908) in Illinois.

Coelosphaerium kützingianum Naeg. Recorded three times from Station III and once from each of the other stations. Very small numbers in all cases. Identification not positive.

Gloeocapsa conglomerata Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	13,685	4,438	11,015	191,027	49,811

Recorded only in July and August at all stations. Identification not positive. Abundant through daily and hourly series and in considerable numbers for the few times taken in the regular series. However, not an important factor so far as these catches indicate. Losses through net probably heavy.

Gloeocapsa spp.

	Station I	Station II	Station III	Daily	Hourly
Average	197,400	141,594	181,426	520,660	539,132

Probably several species are included under this heading. They are found at all stations throughout the year though most abundant in July and August. Losses through the net were probably very heavy and the genus must play an important part in local waters. Identification considered probable though some confusion affected the count at times.

Gomphosphaera aponina Kg.

	Station I	Station II	Station III	Daily	Hourly
Average	7,856	8,968	14,485	726	36,620

Identification uncertain. Occurrence at irregular intervals throughout the year at all stations. Numbers small.

Inactis tinctoria Agardh

	Station I	Station II	Station III	Daily	Hourly
Average	532,790	215,653	594,302	0	105,792

Identification uncertain. None recorded until August. Very few after October at any station. Numbers large while present. Heavy loss through net probable. Evidently of considerable importance in the plankton while present.

Merismopedium glaucus Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	89,512	5,117	6,992	413	210

Identification satisfactory. Losses through net very heavy. Numbers fairly large in November and December. Rarely recorded earlier in year. Small size makes it easy to overlook even when present.

Microcystis sp.

	Station I	Station II	Station III	Daily	Hourly
Average	44,240	64,890	43,646	166,545	364,169

Identification satisfactory. Count probably too low on account of confusion of some colonies with other forms. Found occasionally thrughout the year at all stations. Much more abundant in July, August and September. Loss through net certainly very great. An important member of the plankton, but net catches do not afford a good basis for discussion of its distribution.

Nostoc spp.

	Station I	Station II	Station III	Daily	Hourly
Average	156,435	301,283	459,306	547,678	1,794,781

All the plants included under this head were filaments of the contorted type. The count gives the number of filaments in some cases though usually fragments of colonies constituted the units. Whole colonies were rarely, if ever, found. Possibly three or four species are included in this enumeration. *Nostoc* appeared occasionally throughout the year and became quite prominent in July, August and September. In view of the fragmentary condition of the colonies it is probable that the loss through the net was considerable.

Oscillatoria formosa Bory.

	Station I	Station II	Station III	Daily	Hourly
Average	2,037	45,699	2,205		

Identification uncertain. This form occurred more often at Station II where it was recorded frequently throughout the year, reaching its maximum in June. It does not seem to be very important since its size makes it improbable that loss through the net was very great.

Oscillatoria spp.

	Station I	Station II	Station III	Daily	Hourly
Average	210,437	32,323	49,941	299,126	105,792

Probably three or four species are included under this heading. Found occasionally throughout the year but distinctly a summer form. Maximum in August. *Oscillatoria* of all kinds were nearly always found in single filaments or fragments of filaments. Masses of filaments were rarely seen. This might be considered as supporting Kofoid's suggestion (1908) that physiological conditions may at times make *Oscillatoria* a temporary planktont. On the other hand it does not furnish very definite proof against the view that this form is an adventitious planktont, cast adrift by gas bubbles or violent currents.

Oscillatoria tenuis Agardh.

	Station I	Station II	Station III	Daily	Hourly
Average	46,340	2,404	3,040	154,363	12,207

Identification uncertain. Not a very prominent form. General occurrence much the same as for the above mentioned species.

Phormidium spp.

	Station I	Station II	Station III	Daily	Hourly
Average	121,571	31,248	86,171	25,595	....

Probably includes more than one species. Genus uncertain also. Occurrence occasional through the year. Most abundant at Station I. Maximum in September. Not a very prominent planktont.

Stigonema sp.

	Station I	Station II	Station III	Daily	Hourly
Average	1,317	45,665	8,831	....	....

Identification very doubtful. Filaments always fragmentary. Nothing but vegetative cells seen. Referred to Stigonema partly on account of occasional lateral arrangement of two cells in the filament. Never very prominent. Maximum in June at Station II where it was most often found. Apparently of little importance. Probably adventitious.

The following forms were recorded but once, at one or more stations, or else are listed because thought to be present in living material:

Calothrix sp. Recorded once at Station I.
Clathrocystis aeruginosa Kg.
Cylindrospermum comalum Wood.
Dactylococcopsis rhaphidioides Hausg. Recorded once at Station I.
Gloeocapsa gelatinosa Kütz.
Lyngbya sp. Recorded once at Stations I and II.
Oncobyrsa rivularis Kutz. Recorded once at each station.
Rivularia sp. Recorded once at Station I.
Symplocastrum sp. Recorded once at Station III.

Chlorophyceae

	Station I	Station II	Station III	Daily	Hourly
Number of forms	15	14	17	8	8
Av. numbers per cu. meter	1,811,722	1,499,479	1,789,041	2,179,378	1,703,883

These averages indicate only about one-thirtieth of the number found by Kofoid (1908) in Illinois. Since, however, the main contribution here was made by *Actinastrum, Coelastrum, Pediastrum* and *Scenedesmus* it may be readily understood that losses through the net account for most of the difference. The group was represented through the entire year, though the numbers were often very few. Station I showed the peculiarity of a great increase in numbers in May and June, a decline in July and August, and another well sustained increase in September, October and November. Stations II and III showed only one conspicuous rise in numbers, covering about four months, from July to October inclusive. The numbers occurring in other months were very small. It is quite difficult to determine the cause of the two pulses at Station I as distinguished from the other two stations. It could hardly be temperature since that factor remains too nearly constant during the period involved. The earlier increase in May might be ascribed to the more quiet water rich in organic matter, and the continuance through November might be aided by the sewage. The most probable explanations of the intermediate fall in numbers seems to be that predatory organisms may have been most prominent at that period or that stagnation of the sewage laden water hindered growth and multiplication. The possibility of the last named factor being the more important is supported by the fact that increase comes in September when there begins to be some relief from stagnation by increase of supply from the mountain streams. This relief was not very great in 1913, however, nor is it very well marked in any year. The possibility of interference by other organisms is supported by the fact that the numbers present are mainly influenced by the numbers of *Scenedesmus*, an organism very likely to be extensively used for food by some of the organisms of the zooplankton. Amongst the *Ciliata*, *Vorticella* seems most likely to be responsible while *Asplanchna* is the most prominent of the Rotifera. But the *Copepoda* are still more characteristic of this period and the summer decline of *Scenedesmus* may be due mainly to their activity. *Chlorophyceae* were never very conspicuous in 1913 and they were outnumbered by diatoms 14 to 1 and by *Mastigophora* about 2 to 1. Uncertainty as to the percentages of losses of various forms through the net makes definite conclusion impossible.

The very interesting question concerning recurrent pulses and their relation to lunar cycles, discussed by Kofoid (1908), cannot be answered any more definitely here. It is clear from these net catches that there are recurrent pulses (plates 1–5) at about three to six weeks intervals but there is nothing which warrants more than an indorsement of his provisional conclusion that there may be an increase in number of chlorophyll bearing organisms to correspond with each recurrent increase of light from the moon. It is altogether probable that this problem cannot be solved until some one is able to carry a long series of daily catches, carefully timed, and by more accurate methods than those of the silk net. Whether any filter method would suffice is hard to say. It was hoped that the daily series carried for thirty-one days in 1913 would help to solve this problem but it presented no conclusive evidence. (Pl. 6.)

Thirty forms were recorded in the count and it was thought that several others were recognized in the living material. Certainly there were more species present. So far as net catches indicate, *Pediastrum* was the leader both numerically and volumetrically, at Stations II and III. At Station I it was not far different from *Scenedesmus* in numbers (coenobia counted) and of course, exceeded it in volume of catch. *Scenedesmus* was clearly second in importance, *Actinastrum* third and *Coelastrum* fourth. *Crucigenia, Raphidium, Richteriella* and *Schroederia* were frequently found. In view of the common occurrence of *Botryococcus* in other places its scarcity here needs explanation. Failure to identify seems to be the most probable reason, though it may actually have been absent usually.

Present methods do not show the dilute sewage water of Stockton Channel to be much more productive of *Chlorophyceae* than the river. Hence such evidence as we get from this study only weakly supports Kofoid's suggestion (1908) that sewage laden waters favor the increase in numbers of the group. At any rate there is clear indication that the *Chlorophyceae* contribute largely to the plankton at all stations.

DISCUSSION OF SPECIES

Actinastrum hantzschii Lagerh.

	Station I	Station II	Station III	Daily	Hourly
Average	51,050	216,851	257,954	36,939	392,439

Identification satisfactory. The combined averages of two varieties of this species are given here. They are recorded separately in tables 1 to 5. The only difference noted was in size, the one recorded as "large" being from two to four times as large as the typical form measured by length of the cell. As might be expected, it is largely responsible for the enormous average here as compared with the silk net average (338) in Illinois. Without it, however, the average is much greater, thus indicating a distinctly greater prevalence of the species here. It will be noticed too that Stockton Channel with its dilute sewage shows only about one-fourth of the average numbers produced by the other stations. The typical form was found occasionally at all stations throughout the year and it also reached its greatest abundance at the same three periods at all stations, i.e., March, June and September, the last showing the maximum. The large variety came in late (April and May), produced a weak pulse in July, and strong pulses in August and October; it dropped out again in November. Apparently temperature affected it much more definitely than it did the typical form. Temperature is not the deciding factor, however, as is shown by the fact that this variety appeared last in the warmer water of Stockton Channel whence it also practically disappeared first. Its lower temperature limit seems to be about 14° C. Stockton Channel was distinctly less favorable to the large form than to the typical form as is shown by the difference in numbers being greater there than at the other two stations (tables 1 to 3). Gradations in size between the two forms sometimes made separation difficult. This species is evidently of considerable importance here.

Coelastrum microporum Naeg.

	Station I	Station II	Station III	Daily	Hourly
Average	190,313	31,595	60,819	143,454	107,761

Identification satisfactory. Possibly includes at least two other species. Coenobia counted. Was not found at Stations II and III until July, and only five times before that at Station I. Maximum in September at all stations. Last appearance on December 14 at Station I, a month later than at the other places. Obviously favored by the slightly higher temperature of Stockton Channel. The difference in averages also suggests a distinct preference for sewage water. The maximum in September, when there was little disturbance of the waters, may indicate great susceptibility to action of strong currents and to rising and falling flood waters with their rapid changes in temperature. The September pulse is the only distinct one. In view of the enormous losses through the net, *Coelastrum* must be reckoned as an important planktont, though it is mainly limited to temperatures above 15° C.

Crucigenia lauterbornii Schmidle.

	Station I	Station II	Station III	Daily	Hourly
Average	....	....	....	....	....

Identification fairly satisfactory. Recorded once from Station II, four times from Station III. Average of colonies for the year at Station III, 14,771. Clearly too small for accurate study by net methods. Occurrence in September and October.

Pediastrum boryanum Menegh.

	Station I	Station II	Station III	Daily	Hourly
Average	9,913	41,265	72,153	12,612	37,474

Identification inexact. Coenobia with bicornate marginal cells but without intercellular spaces were counted under this head. Various gradations and differences in detail make it seem probable, as Kofoid (1908) found in Illinois, that at least two or three species may at times be represented in the count.

Present throughout the year at all stations. Missing irregularly in almost every month at Station I, less often at the other two. Very few in January and December. Distinctly more numerous at all stations than in Illinois. Sewage water evidently less favorable for its development. All stations show a March pulse of some moment and another in September. There is some evidence of recurrent pulses corresponding to lunar cycles, strongest at Station II. Maxima in September at Stations I and II, October at Station III. The most consistent record at Station I is in March and November, indicating a preference in sewage water for temperatures from 13° C. to 19° C. Since the only misses at Station II are in May, June and December the same inference might be drawn as to temperature if it were not for the fact that the representation was well sustained through August to November. Somewhat similar conditions were shown by Station III. At all stations the fluctuations were well marked at all seasons. This was even more true of the daily series at Station I (table 4) than of the regular series. The fluctuations of the first half year may be mainly due to rise and fall of flood waters. It is more difficult to account for those of the succeeding four months under relatively stable conditions.

Pediastrum duplex Meyen.

	Station I	Station II	Station III	Daily	Hourly
Average	301,913	686,539	837,875	703,005	1,613,919

Diagnosis inexact. All the coenobia with more or less bicornate marginal cells showing distinct intercellular spaces were counted under this head. The assemblage as a whole is fairly constant to a provisional type and is quite possibly a single species. It was also different from the preceding form in its larger numbers, greater constancy of occurrence and greater regularity of development. Then too, this species has a more uniform chronology at all stations. There is a vernal pulse with maximum in March and an autumnal pulse with maximum in October. The marked decline after March is evidently chargeable in some way to flood conditions. The steady rise from July through August and September to the October maximum is just as evidently due to warmer temperature and greater stability. Though *P. duplex* is present at all stations through the whole year its optimum temperature is clearly near 20° C. The comparatively small numbers in Stockton Channel indicate that much sewage is detrimental. By similar reasoning it might be concluded that Smith Canal (Station III) supported a larger number than the river (Station II) because more organic matter is beneficial up to a certain point. Such a conclusion is not entirely warranted, however, because the river has an open channel with some flow while the other is closed at one end. This difference alone might amount to more than the organic content.

The indication of recurrent cycles due to lunar influence is more distinct with this form than the preceding though they are not at all regular even here (tables 1 to 3). The daily series shows an interesting suggestion of recurrent pulses at intervals of four to six days (table 4). In the hourly series (table 5), it appears that both *P. boryanum* and *P. duplex* reach maxima in the afternoon, suggesting diurnal influence of light and temperature. The data, however, do not warrant a conclusion. The hourly series needs extension.

There is no very definite relation of *Pediastrum* pulses to the volumetric pulses.

Pediastrum simplex Meyen.

	Station I	Station II	Station III	Daily	Hourly
Average .	7,422	32,333	36,044	16,796	49,189

Identification fairly satisfactory. Coenobia having marginal cells with one median spine were counted under this head. Probably only one species included. Fewer than either of the foregoing forms at all stations, except that it exceeds *P. boryanum* in both the daily and hourly series. Rare at Station I through the first six months, considerable numbers there in July, very few in August, maximum in September, rare thereafter. Occurrence at the other two stations similar, except that the numbers were larger. So far as the records go they indicate the same general characteristics of distribution as mentioned for the foregoing species.

It is evident that *Pediastrum* is a very important genus, both numerically and volumetrically in the local plankton. The greater numbers here, as compared with Illinois, indicate that local conditions are better suited to this genus, but it is also true that this may have been an exceptionally favorable year. It is worth noting in this connection that the representation of *Pediastrum* is proportionally greater here as compared with other forms found in both sections and this fact favors the view that it is really more characteristic of our plankton.

Since the genus shows very distinct response to flood conditions, perhaps it is worth while to emphasize that point, especially in view of the fact that there are no reliable water gauge or tide records available. The rapid decline of numbers in March follows very closely on the arrival of the heavy stream flow from the mountains. The rapid rise in numbers in June is just as closely connected with the disappearance of flood waters.

Raphidium polymorphum Fres.

	Station I	Station II	Station III	Daily	Hourly
Average	131,037	48,363	47,002	129,935	29,744

Diagnosis inexact. Probably includes two or more species. Occurrence rare in winter months at all stations. Thrives best in Stockton Channel (Station I). While the numbers are large at times the records are so fragmentary, particularly in view of the enormous numbers escaping through the net, that no generalization can be made. There is, however, some support for Kofoid's observation (1908) that the organism has an optimum temperature above 15° C. Furthermore the larger numbers in Stockton Channel indicate the benefits of sewage.

Richteriella botryoides Lemm.

	Station I	Station II	Station III	Daily	Hourly
Average	5,723	20,806	27,499	....	....

Identification satisfactory. Occurrence at very irregular intervals at all seasons of the year and at all stations. Rather large numbers at times. Records too scant to warrant conclusions. Percentage captured evidently very small.

Scenedesmus obliquus Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	319,244	43,593	63,234	305,638	166,826

Diagnosis sometimes confused on account of apparent intergradations. May perhaps include two or three species. Rare in January and February. Few in March, April, May and December at all stations. Maximum in June at Station I, although the numbers are best sustained there through September and October. Other stations also show greater constancy in that period. Vernal pulse very slight so far as silk net can show. Average silk net catch in Illinois was given by Kofoid (1908) as 673. The largest Stockton Channel catch is about 500 times as great. If the silk net only captures a fraction of 1 per cent of the *Scenedesmus* present the numbers there were certainly enormous. In spite of the losses through the net it is at least safe to say that sewage and moderate temperature, 15° C. to 20° C. are especially favorable to this form. There are recurrent pulses apparently but the uncertainty as to the percentage of the population on record makes all such points unreliable.

Scenedesmus quadricauda Breb.

	Station I	Station II	Station III	Daily	Hourly
Average	772,520	224,775	363,308	786,615	366,203

Diagnosis sometimes confused by intergradations. Only a small percentage in doubt. Losses through net certainly very heavy, probably over 99 per cent according to Kofoid's results (1908). Hence inferences are to be made with caution as in case of the preceding species However, the greater continuity of the record for this species makes intelligent discussion possible.

A vernal pulse in March and an autumnal pulse culminating in October were quite well marked at Stations II and III. The vernal pulse is not clear at Station I and the autumnal maximum was reached in November. In no case was there very heavy representation until about June. At Station I a distinct decline through July and August suggests marked limitation by higher temperatures. Sewage water with temperature between 15° C. and 20° C. is evidently nearly ideal for *Scenedesmus*.

There is rather distinct indication of monthly pulses at all three stations (tables 1–3). These do not, however, correspond very closely with *Pediastrum* pulses, so it is hardly worth while to attempt to establish any connection with lunar cycles from present data.

This species was rarely absent from any station, never from Station I. Its appearance there in large numbers through the winter months clearly marks it as perennial in this locality. While the records of this and the preceding species are fragmentary so far as the whole population of the genus is concerned they show very clearly that the genus is of first rate importance in our waters through a large part of the year and especially where there is much organic matter.

Schroederia setigera Lemm.

	Station I	Station II	Station III	Daily	Hourly
Average	35,724	4,099	5,343	43,587	16,276

Identification satisfactory. Probably only small percentage captured by the net. Only recorded six times at Station III and three times at Station II. Irregular occurrence from last of April to end of year at Station I. Well represented through June and part of November. Not enough data to indicate more than a preference for dilute sewage.

Selenastrum bibrainum Reinsch.

Identification satisfactory. Recorded five times from Station I in small numbers. Once at Station III. Evidently too small to be held by the net.

The following forms were recorded only once or twice in small numbers or else were noticed in living material.

Botryococcus sp. Once at Stations II and III. May have been overlooked.
Bulbochaete sp.
Chodatella ciliata. Lemm. Once at Station III.
Crucigenia quadrata Morr. Once in daily series.
Crucigenia rectangularis Chod.
Crucigenia sp. Once at Stations II and III.
Dimorphococcus lunatus A. Br.
Draparnaldia plumosa Ag.
Golenkinia radiata Chod. Once at Stations I and III.
Lagerheimia wratislaviense Schroed. Once at Station I.
Lauterborniella elegantissima Schmidle. Once at Stations I and II.
Monostroma sp. Once at Station III.
Nephrocytium agardhianum Naeg.
Pleurococcus sp.
Sorastrum spinulosum Naeg.
Stigeoclonium (?) sp. Twice at Stations I and II.
Tetrastrum sp. Once at Station III.
Ulothrix sp. Twice at Station I. Doubtful identification.

Bacillariaceae

Plates 7–9

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	44	58	53	25	32
Av. number per cu. meter	22,609,062	39,478,317	36,826,859	28,055,459	29,029,248

The diatoms are distinctly the most abundant group of organisms in San Joaquin plankton so far as present methods show. According to these records they outnumber Schizophyceae 14, 33 and 18 to 1; Chlorophyceae 12, 28 and 21 to 1, and Mastigophora 6, 14 and 7 to 1 at Stations I, II and III respectively, thus making them appear to have a still more prominent place in the plankton than they had in Illinois. There were always some diatoms in every collection at all stations throughout the year.

There was only one very distinct pulse at each station. At Station I this appeared in May, while at the other stations, where it was larger but less abrupt, it came in August. There is no way of telling from these records whether this difference was due to better temperature or to more stable conditions at those times. The fact that Smith Canal resembles the river in temperature and is more like Stockton Channel in stability suggests a stronger influence of temperature. A glance at plates 7, 8 and 9 shows a marked resemblance of all three stations in low production of diatoms through the first twenty and the last six weeks of the year. All show comparatively heavy production through all the intervening period though the culmination is more nearly median in this time at Stations II and III. This characteristic of distribution is common to all the algae. These major pulses are evidently composite though the exact location of their maxima may be due to single species. The diatoms as a group show more marked indication of pulses recurrent at approximately four weeks intervals than do any other algae.

One notable difference in the three stations is that the total production is less at Station I than at either of the others. Except for the difference in the location of the maxima this was shown throughout the year. The production in winter and spring is continuously less at Station I. Although the maximum came earlier it did not appear so abruptly nor decline so quickly as at both Station II and Station III. Sewage seems to be detrimental, as does a temperature above 23° C. However, it is not certain that temperature is the determining factor, for stagnation of the water probably has a deleterious effect more quickly in sewage water than in water comparatively clean. It seems quite possible that simultaneous strong flood currents through Stockton Channel and the river would hold the maximum back to a similar date. Some light on this question may be expected from the 1914 series which covers a time of heavy flood. Again there is the possibility that predatory organisms, notably Entomostraca, cut down the supply of diatoms in spite of favorable conditions for development. The maximum for Entomostraca comes at the time of decline of production of diatoms in the summer (plates 3, 9). .

The fact noted by Kofoid (1908) that the volumetric measure shows mainly the zoöplankton is especially important here because there is not sufficient check by other methods to give any idea of the relative loss of phytoplankton through the net. The diatom count corresponds pretty closely, in its rise and decline, to the volumetric record (plates 1, 7, 8, 9) at Station II and III but no very definite relation appears at Station I. This might be expected from the fact that a moment's examination gives one the impression that the Stockton Channel plankton is distinctly animal and the river plankton mainly plant.

While the records of Station I might lead one to think there possibly were reproductive cycles and successive rest periods as suggested by Kofoid (1908) the records for Stations II and III point rather the other way. The strong and somewhat rapid rise through June and July to a maximum in August with a similar decline to the winter level suggests, indeed, that factors of the immediate external environment are responsible and that increase in numbers would continue indefinitely if the proper balance of temperature, food materials and natural enemies could be secured along with sufficient removal of injurious accumulations.

The number of forms of diatoms listed (98) may seem unwarranted inasmuch as there could be no hope of accurate determination of all the species present. The large list was the cumulative result of an effort to give expression to differences noted. The futility of it was not realized until too late to change it easily. After all, it happens that there are only a few forms found frequently and in great numbers and most of these can be approximately determined.

Twenty forms occur at one or more stations with sufficient continuity to give the impression that they are true planktonts. These are *Asterionella gracillima, Bacillaria paradoxa, Cyclotella* spp. *Cymatopleura solea, Cymbella affinis, Cymbella cymbiformis, Cymbella tumida, Fragillaria capucina, Gyrosigma kützingii, Gyrosigma scalproides, Melosira granulata, Melosira varians, Navicula alpestris, Navicula bacillum, Navicula gracilis, Nitzschia acicularis, Pleurostauron parvulum, Surirella* spp., *Synedra radians, and Synedra ulna* Distinctly the most important of these are *Asterionella, Bacillaria, Cyclotella, Melosira* and *Synedra,* all of which are satisfactorily determined as to genus, though the species are sometimes uncertain. Most of the other genera just mentioned are also believed to be correctly designated. Much of the specific determination is largely guess work for the inexperienced observer under the conditions of counting. Fortunately such errors do not materially affect the generalizations within reach of this present study. Schönfeldt's "Bacillariales" in the *Süsswasserflora Deutschlands* series was the main dependence for identification.

DISCUSSION OF SPECIES

Asterionella gracillima Heib.

	Station I	Station II	Station III	Daily	Hourly
Average	344,378	1,743,406	1,381,583	3,516	12,206

Identification certain. Records show numbers of colonies. Average size of colonies at Station I was three, at Station II four, at Station III three. Two forms were noted, a typical and a large form. They were recorded separately in tables 1 to 5 though the above averages are for the two combined. As in the case of *Actinastrum* the two were alike except for size but the larger was usually only about 50 per cent larger, rarely twice as large. There were sometimes all gradations in size but in most cases the distinction was plain. It will be noticed by reference to the tables that the pulses ran somewhat the same with both forms at all stations but that the large form appeared rather late at all stations and that it was only prominent in May and June at Stations I and II, June at Station III. Perhaps this condition warrants the inference that the large form is favored by a temperature above 20° C. especially since the June maximum comes at the highest temperature (26°5 C. and 29° C. respectively at Stations II and III) and very nearly so at Station I (22° C.).

Both forms were practically absent at all stations through July, August, September and October. Both reappear in November. The typical form is abundant at all stations except during the four months just mentioned. At Station I it showed a strong pulse in January and a maximum pulse in March. Another strong pulse came in December. At both of the other stations the maximum pulse came in February and a very strong pulse in December. If both forms be counted together, Station II is seen to have almost as large a pulse in June as in February. The combination also shows a very large pulse in June at Station III. The abrupt disappearance of both forms in July at all stations must be due to some other factor than temperature since the temperature change is neither abrupt nor very marked. Stagnation may have a strong deterrent influence. There are fairly well marked, recurrent pulses at four to six weeks intervals at all stations.

Very few single cells of *Asterionella* were recorded. This can be accounted for in two ways: first, escape through the net; second, confusion with other single cells.

Amphiprora alata Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	12,847	4,161	21,057	8,373	268,548

Identification satisfactory as to genus and probable as to species. *A. ornata* is probably included in the count at times, as it was sometimes found by the writer and was also identified in 1915 catches by Professor C. J. Elmore. Probably heavy loss through the net. So far as net catches show it is not so very important. Occurrence rather scattering at all stations though fairly constant in latter part of the year at Station I. Maximum at Station I in May, at other stations in June.

Bacillaria paradoxa Gmel.

	Station I	Station II	Station III	Daily	Hourly
Average	8,547	1,647,817	984,810	28,857	254,916

Identification positive. Colonies usually large, hence probably very little loss through the net. Occurrence scattering at Station I, fairly constant through the year at Station II and III where it was abundant through the second half year. Maximum in July at Station I, August 2 at Station II, and August 9 at Station III. Conspicuous minor pulses in April and December at Station II; April, September and December at Station III. The sudden jump into prominence at Stations II and III in July and the reappearance at Station I, where it had been absent more than two months, seems to indicate favorable influence of stagnant water. Retardation by sewage is also indicated. Higher temperatures may have a bearing, though the temperature change is not nearly so abrupt as the change in numbers of *Bacillaria*. There are no very strong indications of recurrent pulses at any station, but Station II shows them slightly.

B. paradoxa is certainly one of the most important planktonts of the river after the flood season. Colonies containing less than ten individual cells were comparatively rare, certainly not more common than those consisting of more than twenty-five. It would be very safe to estimate the average number of cells captured at ten times the average recorded for the colonies. This would bring *B. paradoxa* into the foremost rank of planktonts, numerically, at Stations II and III. Only *Cyclotella* sp. and *Melosira granulata* would clearly exceed it in numbers by that reckoning. The other forms which might do so are not identified with sufficient certainty.

Cocconeis pediculus Ehrbg.

Determination probable. May include other species. Losses through net undoubtedly heavy. According to the records not a very important planktont. Occurs five times at Station I, thirteen times at Station II with a maximum of 105,792 at the end of May, and four times at Station III.

Cyclotella spp.

	Station I	Station II	Station III	Daily	Hourly
Average	15,052,042	6,335,253	6,865,673	13,191,571	5,415,717

Genus identification certain. Probably includes three or more species, certainly two. Impossible to distinguish species completely while counting though the attempt was made throughout the whole series for 1913. It was finally decided that more accurate conclusions were probable if all counts were thrown together. So few individuals are retained by the net that any conclusion must be taken with caution even then. Present through the year in all collections at all stations. Wide range in size. Most of them nearer the smaller limit as noted by Kofoid (1908).

Maximum numbers at Station I in June, at both of the other stations in October. One minor pulse is of unusual interest because it falls on January 19 at all three stations (tables 1–3). There is no great change in temperature to account for it but it came after a week of cloudy weather with more or less rain on the five days immediately preceding. It would seem that the condition of falling flood is responsible in this case. Possibly the June maximum at Station I can be explained in the same way. No such local conditions apply in case of the October maximum at Stations II and III. There was, however, about that time higher water than there had been for several weeks previous, due to the inflow from mountain tributaries enlarged by the early mountain rains.

So far as our present records show, the optimum temperature seems to be nearer 20° C. than 15° C. as found by Kofoid (1908) in Illinois. Sewage contamination, stagnation and flood waters all appear to be factors of marked importance in determining maximal production of this diatom. There is no indication of a maximum corresponding to the volumetric maximum (plate 1) such as was observed in Illinois, but this may be due to the small numbers caught as compared with those escaping.

Cymatopleura solea Breb.

	Station I	Station II	Station III	Daily	Hourly
Average	219	11,043	3,796	....	....

Identification satisfactory. Recorded only six times at Station I, but found at intervals through whole year at other stations. Numbers rather small. Loss through net considerable. Maximum in May at Station II with a well defined pulse. Maximum in August at Station III where there were no definite pulses. May be adventitious. Temperatures at maxima were above 20° C.

Cymbella affinis Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	1,283	73,671	10,276	516	20,345

Identification uncertain. This was a very small *Cymbella* relatively few of which could have been retained by the net. Recorded only eleven times at Station I. Abundant in March, April, May and June at Station II but missing in January, February and December. Scattering in other months. Maximum on May 31 in a well developed pulse. More irregular in occurrence at Station III where the maximum came in April. Probably an important planktont numerically. Evidently not favored by sewage.

Cymbella cymbiformis Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	446	8,382	4,331	310	4,561

Identification uncertain. Probably includes more than one species not distinguishable while counting. Recorded thirteen times at wide intervals at Station I, in small numbers. Small numbers recorded in every month of the year at Stations I and III with a fairly constant record through May and June at Station II. Apparently of minor importance.

Cymbella tumida Breb.

	Station I	Station II	Station III	Daily	Hourly
Average	2,245	23,677	3,547	619	5,546

Identification uncertain. Probably includes more than one species. Records scattering and in small numbers at Station I. Small numbers but fairly constant, May to September, at Station III. Recorded in every month except January and September at Station II. Maximum in May. Probably of minor importance.

Epithemia ocellata Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	1,015	15,713	3,579	413	8,630

Identification fairly satisfactory. Probably two other species included. Loss through net heavy. Numbers small and records scattering at Stations I and III. Representation fairly constant at Station II except in January, February and December. Maximum in May on a well marked pulse. May be adventitious since the maximum comes on the waters of the mountain flood.

Fragillaria capucina Desm.

	Station I	Station II	Station III	Daily	Hourly
Average	1,154	26,252	25,563		9,123

Identification satisfactory. Colonies usually rather large, seldom less than six cells. Most of the colonies probably retained, though loss of small colonies and single cells may have been heavy. Numbers very small at Station I and records few after April. Numbers larger and occurrence more constant at Stations II and III, though frequently missing there after August. Maximum in May at both places. No other pulse of particular note. Apparently not very important.

Fragillaria crotonensis Kitton.

	Station I	Station II	Station III	Daily	Hourly
Average	92	4,516	7,888		

Identification satisfactory. Colonies not very large. Occurrence twice at Station I, seven times at Station II at wide intervals and nine times at Station III. The records at Station III are mainly in September, October and November. Evidently unimportant here in spite of considerable escape from net in catches.

Fragillaria spp.

	Station I	Station II	Station III	Daily	Hourly
Average	92	27,832	290	103	

Probably most of those included under this heading belonged to *F. virescens*. Occurrence only twice at Station I. Represented at Station II by some fairly large numbers widely scattered. Colonies small. Apparently adventitious.

Gomphonema constrictum Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	1,322	22,094	282	103	8,138

Identification uncertain. Numbers small. Losses through net heavy. Recorded seven times at Station I at irregular intervals. Well represented in May and June at Station II. Recorded seven times at Station III in very small numbers.

Gomphonema spp.

	Station I	Station II	Station III	Daily	Hourly
Average	65	6,419	5,000	103	

Under this heading are included some members of this group which could not be placed satisfactorily. Probably most of them were *G. subclavatum*. Apparently there were five or six species of this genus observed at various times and it probably has some importance though it may be adventitious.

Gyrosigma acuminatum Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	1,232	24,920	22,157		12,207

Identification uncertain. Recorded seven times at Station I at wide intervals, twelve times at Station II and Station III. Grouped in August at Station III. Considering amount of loss through net may have some importance though evidently adventitious.

Gyrosigma. kützingii Grun.

	Station I	Station II	Station III	Daily	Hourly
Average	3,330	102,723	70,433	1,032	87,974

Identification probable. Losses through net very heavy. Recorded frequently in small numbers in every month except February, June, and July at Station I. Maximum there in September. Occurred regularly with only one or two breaks at Stations II and III. Maximum at Station II in late August in a well developed pulse. Maximum at Station III in late July at the beginning of a similar pulse which almost reached the maximum again at the same time with Station II. Minor pulses at from two to six weeks intervals through most of the year were rather prominent at both stations. Apparently this is a planktont of some importance throughout the year since the percentage retained by the net is undoubtedly small.

Gryrosigma scalproides Rabenh.

	Station I	Station II	Station III	Daily	Hourly
Average	13,733	31,294	206,444	826	480,133

Identification satisfactory. May include *G. spenceri* W. Sm. Loss through net heavy. Records scattering at Station I especially in first seven months. Maximum in August with a well developed pulse. Recorded in every month up to September and not later, at Station II, with a sharp pulse in August. Recorded every month after January and February at Station III though scattering until late July. Very strong pulse in August reaching apex on August 23. Seems to be, like other *Gyrosigma,* a seasonal planktont favored by temperatures above 20° C. and injured by sewage.

Melosira granulata Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	2,305,175	25,163,409	22,821,226	1,880,779	18,144,471

Identification certain. Mostly variety *spinosa.* Loss through net high. Kofoid (1908) says about 98 per cent in Illinois and it is doubtless nearly the same here. His observation that silk catches showed the same seasonal routine as the filter catches makes it seem probable that we can use our counts here with some confidence in the conclusions they may indicate. *M. granulata* is recorded in every collection through the whole year at all stations. At all stations the numbers are comparatively small until April, though the million mark was reached a few times before that date at each. The earliest count of this size was at Station I in January. The maximum at all stations falls on September 6, after a considerable period of rather high temperatures. A temperature of 25° C. or higher and stagnation of the water are at least two favorable factors in production. Since Station I has less than 10 per cent of the number at the other stations at that time it seems equally clear that sewage is detrimental. So far as the 1913 collections show, there is a rather definite growth period in September, though there are several prominent pulses through the warm season just as there were in Illinois. Minor pulses at from two to six weeks intervals were quite prominent characteristics of the occurrence of this organism everywhere. The steady decline from the September maximum in spite of occasional minor pulses strongly supports Kofoid's view that temperature is the most potent factor influencing production.

The time of maximum production corresponds fairly well with the time of greatest production of total plankton mass (plate 1), though the largest number is reached a little later. It is, however, coincident with the maximum of the total count of organisms. To this last total *M. granulata* contributes largely since it is the most abundant local planktont at Stations II and 111. Owing to its large numbers it also contributes a very considerable mass.

There was a good deal of variability in this species. Spines varied from very coarse, prominent projections to none. Granulation was very prominent in some cases, absent in others. There was a wide variation in size. This was so great that for a time a small form was listed as *M. granulata A* and counted separately (tables 1–3). By so doing the main count was fairly well restricted to the more nearly typical *granulata* and to the variety *spinosa*. Sometimes these seemed to be nearly equal in numbers but usually the spinous form was less noticed than the other.

Various encumbrances of the filaments were common. None of these were certainly identified. The only one counted was a small Rotifer egg listed as *Diurella* sp., by guess.

No effort was made to determine the average number of cells in a filament but it was probably not less than five. The cells composing a filament were much longer in proportion to width than they were figured in the literature consulted. A common form about the time of maximum numbers had cells about five times as long as wide.

Melosira varians Ag.

	Station I	Station II	Station III	Daily	Hourly
Average	4,682	233,227	93,884	619	9,123

Identification satisfactory. Losses through net heavy. Occurrence at Station I quite irregular in small numbers, with a maximum in April. Main production at other stations in first six months, two or three misses after that time at both. Maximum at last of May in Station II after steady increase for several weeks. Maximum in March at Station III, appearing rather abruptly. Recurrent pulses at two to six weeks intervals at both stations. A large September pulse is only indication of response to conditions similar to those of *M. granulata.* In fact the most favorable temperature seems to be near 18° C. or between 12° C. and 20° C. There is a strong pulse in late December at Station II which follows about a month of temperatures below 10° C. Hence it is certain that the two species are distinctly different in the responses to temperature. While *M. varians is* overshadowed in productiveness by *M. granulata,* it is yet to be reckoned an important planktont here.

Navicula affinis Ehrbg.

Identification doubtful. Losses through net heavy. Recorded eleven and eight times at Stations II and 111 respectively in rather small numbers. Not sufficient data for discussion.

Navicula alpestris Grun.

	Station I	Station II	Station III	Daily	Hourly
Average	6,746	76,645	29,979	3,929	55,357

Identification doubtful. Losses through net very heavy. Occurrence at Station I in small numbers and very scattering through the year. Not much better record at Station III. Appears in March at Stations II and III. Maximum at Station II on May 31 after two months of fairly steady increase, followed by slow decline to August. Seems to be favored by moving water. Its long continued presence seems to indicate that it is a true planktont, and it is probably of considerable importance.

Navicula bacillum Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	56,910	169,399	42,869	16,079	65,103

Identification doubtful. Percentage retained by net must be very small. It may seem a waste of time to list so many diatoms of uncertain identity, especially of the smaller forms, but it is the writer's opinion that to do so may serve two purposes: first, to give a faint idea of the large number of forms present; second, to show how very many forms there are beyond the reach of ordinary quantitative methods. For example the small diatom listed under this present heading was quite probably present in one hundred times the numbers recorded, possibly more. It appears in April at all stations and is erratic in appearance and numbers after that. The maximum appears in September at Station I and Station III but in June at Station II. In the circumstances no safe conclusions can be drawn from such a small organism.

Navicula didyma Ehrbg.

Identification doubtful. Losses through net heavy. Recorded once at Station I, ten times at Stations II and III, always in small numbers.

Navicula dubia Ehrbg.

Identification doubtful. Losses through net heavy. Recorded six times at Station I, four times at Station II and five times at Station III in small numbers.

Navicula gracilis Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	209,568	722,906	1,514,448	166,204	1,177,953

Identification uncertain. Losses through net very heavy. Recorded in every month at all stations. Maximum in August at all stations on a rather abrupt rise in numbers. Certainly favored by higher temperatures and quiet water but hindered by sewage. These points are shown by the remarkable development at Station III with quiet water but with little sewage and by the fact that the large numbers shown by Station II through May probably came from the washing out of some sloughs where there had been a time of quiet just preceding. Recurrent pulses are fairly well marked. This form is evidently very important numerically. The count may include several species.

Navicula sp.

Under this head are included a number of forms thought to be *Navicula*. Some of these were first recorded as *N. oblonga, N. pusilla, N. rhomboides* and *N. smithii,* but the numbers were few and the identity uncertain, so it was more convenient to place them this way. There is nothing of particular importance to be obtained even from the combined record.

Navicula viridis Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	169	27,659	4,488	....	985

Identification satisfactory. Losses through net probably heavy. Numbers very small at Stations I and III. Maximum in May at Station II where the numbers were larger and there were few collections showing none. For purposes of discussion it is unfortunate that the only *Navicula* named with confidence presents too few numbers to warrant much attention.

Nitzschia acicularis Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	2,878,662	316,042	476,223	4,390,368	600,166

Identification satisfactory. Probably very small percentage retained by net. Present throughout the year at all stations. Maxima in June at Stations I and II, in late August at Station III. Numbers well sustained through summer at all stations, with a conspicuous September pulse. Evidently a summer planktont favored by temperatures above 20° C. Just as evidently favored by the sewage at Station I as shown by the enormous averages there in comparison with the averages at other stations. Recurrent pulses fairly well marked. Certainly of great numerical importance though its small size would keep the volumetric showing low.

Nitzschia spp.

Under this heading are discussed four or more species of *Nitzschia* all but one of which are doubtful as to identification. *Nitzschia angularis* was satisfactorily determined but *N. sigma, sigmoidea* and *vermicularis* were all somewhat doubtful, at least sometimes. They were all listed separately in the tables but the occurrence was so erratic and the probable losses from the net so heavy that it hardly seemed worth while to attempt to draw any conclusions from the records of any of them. It might be noted, however, that all *Nitzschia* are favored by higher temperatures, but that none of these do well in sewage, *N.*

acicularis being exceptional in that respect. It may also be the only true planktont, all the others being adventitious.

Pleurostauron parvulum Grun.

	Station I	Station II	Station III	Daily	Hourly
Average	34,372	261,925	149,609	310	28,521

Identification probable. Probably very small percentage retained by net. Almost entirely absent from Station I through July, August and September. Few during last half of year. Maximum in May at Stations I and II and in March at Station III. Heavier representation in first half year at all stations. Hence it appears to be favored by flood waters and lower temperatures. Larger numbers at Station II and III indicate bad effects of sewage at Station I. Must be of numerical importance.

Stauroneis phoenicenteron Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	115	5,746	1,320	....	8,138

Identification satisfactory. Losses through net probably heavy. Found at various times of year at all stations but in small numbers. Recorded only six times at Stations I and III. Maximum in May at Station II. Probably adventitious.

Surirella spp.

	Station I	Station II	Station III	Daily	Hourly
Average	14,270	753,747	404,242	12,303	305,828

Genus identification certain. Probably at least four species included under this heading. Losses through net heavy. Present through year at all stations. Maximum in August at Stations II and III. The representation at Station I was light and scattering and though the maximum came in May it cannot be considered very important, especially since large pulses came at that time at the other stations. This planktont is evidently favored by temperatures above 20° C. and retarded by sewage. Both in numbers and volume it makes an important contribution to the plankton population.

Synedra radians Kütz.

	Station I	Station II	Station III	Daily	Hourly
Average	389,043	144,508	194,502	1,126,141	486,236

Identification doubtful. Probably very small percentage retained by net. This is one of those very small forms so difficult to handle in a count. Its appearance on the record at mid-July is simply due to the fact that its continued presence seemed to demand some definite notice. The occurrence before that date must be ignored because of failure to decide to record it. There is enough record to indicate that it is a warm weather form and not nearly so well represented in the colder months.

Synedra ulna Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	655,730	730,339	744,781	2,351,197	305,169

Identification uncertain. Probably includes at least three or four other species with possibly some similar genera. This probably accounts for the similarity of numbers and distribution at all stations. Maximum in August at Stations II and III, in June at Station I with a large pulse in August. Certainly favored by higher temperatures. Losses through net heavy. An important local planktont.

Tabellaria spp.

Identification of genus satisfactory. Occurrence at all stations rare. Evidently unimportant here. It was thought that both *T. fenestrata* and *T. flocculosa* were recognized a few times. This genus is apparently no more at home here than Kofoid (1908) reported it to be in Illinois.

The following forms of Bacillariaceae were recorded only once or twice at the three stations, or were thought to be recognized in living material:

Amphora coffeaeformis Ag. Once, I and twice, III.
Amphora sp. Once, I and III.
Cocconeis placentula Ehrbg. Once, II.
Cocconeis sp.
Coscinodiscus sp. Once Stations I and III and daily.
Cyclotella schroeteri Lemm. Once, I.
Cymbella helvetica Kütz. Once, II and III.
Cymbella lanceolata Ehrbg.
Cymbella parva W. Sm. Twice, I, once at II and III.
Cymbella pusilla Grun.
Cymbella prostrata Berk.
Denticula sp.
Diatoma sp.
Diatoma vulgare Bory. Twice, I, once at III.
Diatomella sp. Grev. Once, I and II.
Epithemia granulata Ehrbg.
Epithemia sorex Kütz. Once, III.
Epithemia sp.
Epithemia turgida Ehrbg. Once, II.
Eunotia flexuosa Kütz. Once at Station I, twice at III.
Eunotia major W. Sm. Once, III.
Eunotia pectinalis Kütz.
Fragillaria mutabilis.

Gomphonema acuminatum Ehrbg. Once, III.
Gomphonema olivaceum Lyngb. Twice, III.
Gomphonema subclavatum Grun.
Gyrosigma attenuatum Kütz. Once, III.
Mastogloia braunii Grun. Twice, II and III.
Mastogloia sp. Once, II.
Melosira subflexilis Kütz. Once, II.
Navicula helvetica J. Brun. Once, III.
Navicula lanceolata Kütz. Once, II.
Navicula oblonga Kütz.
Navicula pusilla W. Sm.
Navicula rhomboides Ehrbg.
Navicula smithii Breb.
Nitzschia dubia W. Sm. Once, II.
Nitzschia gracilis Hantzsch. Once, III.
Pinnularia acrosphaeria Breb. Once, III.
Pleurostauron obtusum Lagerst. Once, I and II.
Rhizosolenia longiseta Zach. Once, I and III.
Rhopalodia gibba O. Müll. Once, I, twice, II.
Rhopalodia paralella O. Müll. Once, II.
Stephanodiscus sp. Twice, I, once, II.
Surirella spiralis Kütz. Once, II.

The following list of forms, identified by Professor C. J. Elmore of Grand Island College in Nebraska from material collected in 1915 and sent to him for naming, will prove of interest for comparison.

Achnanthes lanceolata (Breb) Grun.
Amphora ovalis.
Asterionella gracillima Heib.
Amphiprora ornata Bailey.
Bacillaria paradoxa Gmel.
Ceratoneis arcus Ehr.
Cocconeis pediculus Ehr
Cyclotella meneghiniana Kütz.
Cymatopleura solea (Breb) Grun.
Cymatopleura elliptica (Kütz) W. Sm.
Cymbella gastroides Kütz.
Cymbella lanceolata.
Cymbella pusilla.
Diploneis (Navicula) elliptica.
Encyonema turgidum (Greg) Grun.
Epithemia gibba (Ehr) Kütz.
Epithemia ocellata Kütz.
Epithemia turgida Ehr.
Eunotia robusta.
Fragilaria capucina Desm.
Gomphonema montanum.
Gomphonema constrictum Ehr.
Gyrosigma kützingii (Grun) Cl.
Gyrosigma parkerii.
Gyrosigma scalproides (Rabenh) Cl.

Gyrosigma spencerii (W. Sm) Cl.
Homoeocladia (Nitzschia) acicularis.
Homoeocladia amphioxys.
Homoeocladie obtusa.
Homoeocladia sigma.
Homoeocladia spectabilis.
Homoeocladia tryblionella.
Melosira granulata (Ehr) Ralfs.
Melosira crenulata Ehr.
Melosira distans. Kütz.
Melosira varians Ag.
Navicula ambigua.
Navicula borealis.
Navicula cryptocephala Kütz.
Navicula iridis.
Navicula fulva.
Navicula lanceolata Kütz.
Navicula parva (Ehr).
Navicula pupula Kütz.
Navicula pygmaea.
Navicula rhynchocephala Kütz.
Navicula viridis (Nitz) Kütz.
Nitzschia vermicularis Kütz.
Odontidium elongatum (Ag) Kuntze.
Sphinctocystis librilis.
Stauroneis anceps.
Stauroneis phoenicenteron.
Surirella biseriata.
Surirella ovalis.
Surirella robusta.
Surirella spiralis.
Synedra acus Kütz.
Synedra capitata.
Synedra radians Kütz.
Sypedra ulna Ehr.
Tabellaria fenestrata Kütz.

Conjugatae

	Station I	Station II	Station III	Daily	Hourly
Number of forms listed....	10	15	13	5	5
Average number of individuals per cubic meter	121,653	331,687	420,463	26,827	931,948

The representation for this group is mainly desmid but there were a few filamentous forms such as *Spirogyra* included occasionally. These latter occurred in such small quantities, however, that they had no appreciable volumetric effect and the count serves to show their relative importance quite clearly. Including one form of *Spirogyra* there are seven species of Conjugatae listed here which will be given separate discussion. Even among the desmids the number of individuals was not great.

DISCUSSION OF SPECIES

Closterium acerosum Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	539	7,108	6,161	206	10,961

Identification uncertain. Losses through net probably large. Occurrence rare, irregular and in small numbers at Station I. Found at almost all times of year at other stations. Maximum in September at both. Evidently favored by higher temperatures.

Closterium acuminatum.

Identification doubtful. Recorded three times at Station II and five times at Station III.

Closterium rostratum Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	21,580	8,322	4,494	929	3,045

Identification satisfactory. Losses through net probably large. Recorded only seven times at Station II, five times at Station III and occurrence rare at Station I until late summer. Maximum at Station I in August. Distinctly a summer planktont. Apparently favored by sewage.

Mougeotia sp.

	Station I	Station II	Station III	Daily	Hourly
Average	75,517	262,429	269,657	23,118	793,870

Identification of genus satisfactory. This was decidedly the most abundant of the filamentous Conjugate. Rather prominent at all stations in July, August and September with maximum in last week of August or first of September. Not found often or in large numbers at other times. Favored by temperatures above 20° C. and somewhat hindered in development by sewage.

Spirogyra protecta Wood.

Identification uncertain. Occurred once at Station I, five times at Station II and nine times at Station III. Never in very large numbers. So far as catches show it is unimportant in every way.

Staurastrum sp. *A.*

	Station I	Station II	Station III	Daily	Hourly
Average	8,741	97,529	128,529	1,548	87,419

Genus certain. Species description not found in any literature available. Only the more voluminous references at the University of

California have been consulted, however. This *Staurastrum* is the most delicate and graceful of any ever observed by the present writer. Losses through net probably very heavy. Occurrence as recorded at Station I, small in numbers and scattered; May is the only month yielding none. More abundant at other stations but missing in January and May. Maximum in September at all stations. This comes after several weeks of strong development at Stations II and III. Evidently favored by higher temperatures, 20° C. or above, but hindered by sewage. Probably of considerable importance in summer.

Staurastrum spp.

	Station I	Station II	Station III	Daily	Hourly
Average	3,566	38,901	37,338	826	12,207

Probably three or more *Staurastrum* are included under this heading. There were a large number of different kinds found at various times at different stations. All seem to be rather closely confined to the warm season and to the water with least sewage.

The following forms of Conjugatae were recorded only once or twice or were thought to have been recognized in living material.

Closterium gracile Breb.
Closterium lineatum Ehrbg. Once, III.
Closterium lunula Ehrbg. Once, II, and III.
Closterium obtusum Breb. Once, II.
Cosmarium botrytis Menegh.
Cosmocladium saxonicum DeBy.
Didymoprium sp.
Docidium sp.
Sphaerozosma vertebratum Ralfs.
Spirogyra fluviatilis Hilse. Once, II.
Spirogyra majuscula Kütz. Once, II.
Spondylosium depressum Arch.
Staurastrum alternans Breb. Once, III.
Staurastrum cuspidatum Breb.
Staurastrum eustephanum Ehrbg. Once, I and Daily.
Staurastrum macrocercum.
Staurastrum vestitum Ralfs.
Xanthidium sp.
Zygnema sp.

CHLOROPHYLL BEARING ORGANISMS

So few flagellates were found that were clearly non-chlorophyll bearing, there was so much difficulty in separating the two types, and the characteristics of the Mastigophora so clearly resembled those of the algae, that it was finally decided to give a list of totals of algae (except Bacteriaceae) plus Mastigophora under the heading of chlorophyll bearing organisms (tables 1–5). This plan was also followed with the graphs in plates 3 to 6. A separate list of algae is given under headings of Total Phytoplanktonts (text table 1, p. 31), but no graph was made for it as the slight apparent difference did not seem to warrant it.

It will be noticed that this combination shows marked coherence through the year. There is a rather prominent pulse in every month through the first nine months at Stations I and II and in almost every month at Station III. There is steady increase in numbers from May to September at Stations II and III followed by a steady decline to the end of the year, and at Station I the numbers were well maintained from May to September with a steady decline following. The most striking difference in the three stations concerns the maxima. The maximum came in June at Station I and in September at the other two. The June maximum at Station I was due, however, to the enormous numbers of *Cyclotella* at that period. With *Cyclotella* exerting less influence on the totals or entirely omitted, the general features of occurrence look much the same at Station I as at the other two stations.

The response to higher temperatures is quite noticeable at all stations, the larger numbers being especially characteristic of the time from June to November when the temperature was usually near or above 20° C. This, however, is also the time at which there was least disturbance of the water.

The recurrent pulses were very striking and may be conveniently illustrated by Station II where the dates and intervals ran as follows: January 19, three weeks to February 8, three weeks to March 1, four weeks to March 29, three weeks to April 19, four weeks to May 17, three weeks to June 7, three weeks to June 28, five weeks to August 2, three weeks to August 23, two weeks to September 6, five weeks to October 11, seven weeks to December 6.

Fluctuations at Station II and III also showed a very close correspondence with the volumetric record. This is probably because the algae and Mastigophora furnished a large part of the volume at those stations (plates 1, 4, 5). Such a conclusion is supported by the fact that there is no such correspondence at Station I where the Rotifera and Entomostraca furnish much of the volume (pl. 1, 3).

PROTOZOA

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	75	53	59	26	34
Average number of individuals per cu. meter	5,194,416	3,494,065	3,634,131	3,880,462	7,908,872

The number of forms recorded is 116 but that is certainly considerably less than the real number of species. Identification was very difficult, not only of species but of genera. Many species were indistinguishable under conditions of counting and some that were recorded for a time were abandoned later when high power study showed how great the error was. Distortion of preserved material was a great factor affecting accuracy of counting of Protozoa. Even such strikingly different species as the two stentors, (*S. coeruleus* and *S. niger*) could not be separated with full confidence during the count. For these reasons the list of Protozoa shows more often than that of algae names which include several forms within rather ill defined limits.

Notwithstanding the great diversity of characteristics shown by several prominent protozoan planktonts, the distribution of totals through the year at different stations deserves some attention. The totals of non-flagellated Protozoa at all stations agree in that there is light representation in January, February and December, with an equally well defined heavy representation from May or July to mid-November. Station I averages about 60 per cent higher on its totals than either of the others but its maximum is only slightly greater. The maximum for Station I falls on August 13 but it is almost equalled by a similar pulse in November. The maximum for Station II comes on October 4 and for Station III on August 15, but the latter record is almost equalled by a further pulse on October 4. There is then substantial agreement of all stations in making the best showing as to large numbers and continuity of numbers in late summer and through autumn, when temperatures are rather high, the water quiet and the organic content great.

The inclusion of the Mastigophora with the Protozoa almost destroys the definiteness referred to above. Such a combination shows at Station I a fairly well marked pulse in January, another in March and another in April, followed by a steady increase up to the maximum on September 9. There were then two moderate pulses on the decline, which was otherwise fairly steady to the end of the year. At

Station II there were prominent pulses in January, February, March, May, July and October, while at Station III the prominent pulses came in February, March, April, July, August, September and October. It is thus apparent that the combined history is considerably different at the different stations and that the inclusion of the Mastigophora destroys the coherence of the Protozoa as a group. The totals are given both with and without the Mastigophora in tables 1 to 5 and the reader may suit himself with the list of his preference. See also Plates 12–14.

Mastigophora

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	33	30	31	20	20
Av. number per cu. meter	3,708,569	2,629,112	2,631,702	1,853,429	3,931,892

Almost all of the Mastigophora were too small to be retained by the silk net to any great extent. This is probably the main reason for the fact that the averages recorded are exceeded from twenty-five to forty times by Kofoid's averages (1908) in Illinois. It is certainly true that other factors might be expected to operate, as mentioned before in this paper, but this is so obviously sufficient in itself to account for the difference that it seems useless to inquire further.

Mastigophora were present at all stations throughout the year, although the numbers were quite small for the first few catches. This may be partly due to the fact that the net used before January 15 was of slightly larger mesh than the regular number 25 which was ready by that date. By far the larger proportion of the flagellates came in the last six months, even December showing much more than June There were, however, two or three strong pulses in January and February at all stations. Hence the general indication seems to be that quiet water or even stagnation is about as important as temperature in controlling production. The greater numbers at Station I also indicate that sewage is favorable to this group. The maximum at Station I was reached in September, at Station II in October and at Station III in November. These dates are largely due to *Chromulina* sp., a form very unreliable for suggesting conclusions, both on account of its small size and the uncertainty of identification.

The recurrent pulses of Mastigophora were not so distinct as they were in the case of the total chlorophyll bearing organisms. The semi-weekly collections at Station I seem to obscure them rather than make them more distinct. At any rate the intervals vary from eleven to forty days in a rather indefinite way. Indications at the other two stations are not much better. Evidently we have again too much influence of *Chromulina* in the record. Since the only other flagellate showing very large numbers is *Trachelomonas,* itself very small, it seems hardly worth while to attempt any conclusions from net collections.

Discussion of Species

Ceratium hirundinella O. F. Müll.

Identification satisfactory. Loss through net probably very heavy. Occurrence rare and in small numbers, four times at Station I in September and October. Five times at Station II in June, July, August and September. Three times at Station III in July, September and October.

Cercomonas crassicauda Duj.

Identification satisfactory Loss through net very heavy. Occurrence rare and in small numbers. Recorded at Station I nine times at wide intervals from July to the end of the year. Twice at Station II in July and September. Five times at Station III in June, August and September.

Cercomonas sp.

Identification of genus doubtful. Recorded seven times at Station I in August and September, and once at Station III.

Chlamydomonas sp.

Identification of genus doubtful. Recorded eight times at Station I from July to December, five times at Station II from May to October and twice at Station III in February and May.

Chromulina spp.

	Station I	Station II	Station III	Daily	Hourly
Average	2,760,969	2,225,384	2,241,982	4,136,123	30,256,512

Identification uncertain. May include various minute genera not readily distinguished while counting. Percentage retained by net surely very small. Found in every month at all stations but occasionally not recorded in the first half year. Constantly present after July. Maximum at Station I on September 13, Station II on October 26, and Station III on November 22. Evidently favored by warm and quiet water and not much affected by sewage.

Cryptomonas sp.

Identification doubtful. May be confused with some other forms. Loss through net heavy. Recorded at Station I in considerable numbers in latter part of year. Only once at Station II and four times at Station III. Distinctly favored by sewage and low temperature but relatively indifferent to quiet water by this showing, which agrees pretty well with Kofoid's findings (1908) in Illinois.

Dinobryon sertularia Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	....	11,481	9,993	....	....

Identification of species frequently uncertain. Loss through net probably large. Occurrence rare at Station I and in small numbers of colonies at that. Recorded eleven times at Station II in four, well marked groups at the last of March and May, first half of June and through most of November. Maximum in May and June. Recorded frequently at Station III from March to July and again in November. Absent at other times. Favored by cooler water or flood time and hindered by sewage. Although the numbers here were small the distribution resembles that recorded for Illinois most remarkably. On the present showing it cannot be regarded as a very important planktont here. While not followed very far, the general impression given by the condition of the colonies here leads to support of Kofoid's contention (1908) that the synonymy of this species has been needlessly extended and that all the variant forms might be included under one species name with advantage.

Eudorina elegans Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	11,277	84,275	71,776	9,351	376,375

Identification usually certain. Found throughout the year at Stations II and III with only six scattered periods of absence at each. Numbers much smaller and absences more apparent at Station I where it was only twice recorded in May, entirely absent in August and most of September, last half of October and first half of November. Evidently deleted by sewage. Maximum in October at this station, on August 9 at Station II and III. Contrary to the Illinois record the period of greatest abundance in our river is in the warmest season and almost at greatest stagnation. The complete absence at Station I at this time, however, may throw some light on the Illinois situation. Either the sewage is more injurious to this organism in warmer weather or else its enemies multiply faster under such conditions and so keep it down. The substantial agreement of Stations II and III upon such a point in opposition to Station I makes it almost certain that sewage or organic content is in some way a more influential factor than temperature in the warmer season. There are some indications of recurrent pulses at all stations but they cannot be readily followed through the year. Parasitized colonies were frequently found, especially through the warm season. *Eudorina* is evidently a more important planktont here than in Illinois except at Station I where it is about the same.

One experience in collecting at Station I gives some interesting evidence as to the occurrence of swarms. The regular collection was taken near shore from the boat landing, one morning about 8 o'clock. On examination of the living material under the microscope after reaching home it was found to contain unusual quantities of *Eudorina*. It seemed a favorable time to make a special collection to send to Professor Kofoid so another trip was made to the same spot and hauls taken as nearly as possible in the same way as before. Although there had been a time interval of less than two hours scarcely any *Eudorina* could be found anywhere about. Weather conditions had not changed and there had been no great disturbance of the water by boats as it was on a Sunday morning when the traffic was light.

Euglena deses Ehrbg.

Identification satisfactory. Loss through net heavy. Recorded at Station I five times and once at Station II.

Euglena viridis Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	51,693	11,782	13,592	306,464	28,975

Identification satisfactory. Probably very small percentage retained by net. Occurs mainly in summer and early fall at all stations. Maximum in July at Station I and III, June at Station II. Apparently favored by sewage, quiet water and temperatures above 20° C. Information from silk net catches not reliable beyond this.

Hemidinium nasutum St.

	Station I	Station II	Station III	Daily	Hourly
Average	535,079	28,482	26,967	228,971	293,432

Identification doubtful. Very small percentage retained by net. Recorded only in last half of year at all stations, possibly because not definitely distinguished before. Very few at any station after mid-October. Far more numerous at Station I than at either of the others. Certainly favored by temperatures near or above 20° C. by quiet water and by sewage.

Mallomonas sp.

Identification of genus certain. Recorded three times at Stations I and III in small numbers.

Pandorina morum Bory.

	Station I	Station II	Station III	Daily	Hourly
Average	2,752	16,804	15,457	103	102,150

Identification satisfactory in most cases. May sometimes include young colonies of *Eudorina* or *Pleodorina*. Probably some loss through net. Occurrence at Station I frequent in small numbers through first three months, after that at irregular intervals usually several weeks apart. Fewest in warmer months. Maximum on March 26. At Station II most constant occurrence was through February and March in moderate numbers. Maximum of 105,792 reached in each of the four months of June, July, August and September. At Station III fairly constant in February and March, November and December. Records grouped at irregular intervals between. Maximum in May. Although the records differ strangely at the three stations it seems fair to infer that sewage is deterrent, especially during stagnation but that warmer waters are favorable if stagnation could be avoided. It is possible, however, that the organism was not captured so constantly in warmer waters because those were the quiet waters, hence there were no currents to mix it through the whole body of water. If this be true it is easy to see that the net might at one time traverse a "swarm" of the organisms but miss it entirely at another time.

Peridinium cinctum Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	34,262	5,209	18,732	111,324	12,207

Identification uncertain. Probably very small percentage retained by net. Occurrence rare in first half year at all stations. Recorded only six times at Station II and seven times at Station III. Evidently favored by sewage, since it occurred frequently in rather large numbers at Station I from late June to late November. Maximum apparently in July with most consistent record in September. Evidently favored also by temperature of 20° C. or over, and by quiet water.

Peridinium sp.

Identification of genus satisfactory. Species different from *P. cinctum* but not placed. Recorded four times at Station II three times at Station III.

Phacus pleuronectes Ntz.

	Station I	Station II	Station III	Daily	Hourly
Average	25,375	1,048	1,131	....	....

Identification questionable. Loss through net probably very heavy. Occurrence twice at Station II and thrice at Station III in small numbers. Recorded with only five exceptions at Station I through last three months of year. May have been overlooked before. Kofoid (1908) designates this genus and this species as a summer planktont. The failure of the record here to support fully this view may be due to small size and consequent inaccuracy with silk net catches.

Platydorina caudata Kofoid.

	Station I	Station II	Station III	Daily	Hourly
Average	431	3,569	5,020	206	48,290

Identification positive. Loss through net considerable. Occurrence quite distinctly limited both by temperature and sewage. Recorded only six times at Station I, all at variable intervals from August 2 to November 1 and in very small numbers. Nine occurrences, mainly in August and September at each of the other stations. No case of occurrence in temperature less than 17° C. Maximum at Station I on September 2, Stations II and III on September 13. Considering the small numbers and the short period of occurrence, the similarity of occurrence at the three stations is most remarkable. All stages of development were found and special collections were made for Professor Kofoid in order that he might study some features of development.

Pleodorina californica Shaw.

	Station I	Station II	Station III	Daily	Hourly
Average	123	21,231	6,282	413	67,751

Identification certain. Probably most of the matured colonies were retained by the net. Recorded only twice (in August) at Station I. Evidently strong sewage is deterrent though Kofoid (1908) mentions sewage as probably a factor leading to larger numbers in 1897 than in 1898. Station II showed the only consistent development of this organism. After being recorded in mid-June it was not found until three weeks later when it began an eight weeks period of steady increase to a maximum on August 31, followed by a three weeks decline, after which there were three isolated records. Station III showed no distinct maximum but the nine catches were distributed over about the same period from July to mid-November. It seems clear enough then that too much organic matter, and possibly too great stagnation, is detrimental and that the optimum temperature is above 20° C.

Pleodorina illinoisensis Kofoid.

Identification uncertain. Probably some loss through net. Recorded once at Station I, twice at Station II and four times at Station III, all in small numbers. A puzzling thing about this form is that when examining fresh catches in 1913 the writer was sure he found it frequently and in considerable numbers. Hence he was somewhat surprised at not finding it readily while counting. About the only conclusion possible is that it is very hard to distinguish this form from *Eudorina elegans* in preserved material. Chodat (1902) and others would doubtless say that this fact supports their view that *P. illinoisensis* is only a stage of development of Eudorina.

Pteromonas sp.

Identification probable. Loss through net heavy. Occurrence irregular and rare. Recorded ten times at Station I between June 21 and October 8, three times at Station II and twice at Station III. Apparently favored by sewage, stagnation and higher temperatures.

Spondylomorum quaternarium Ehrbg.

Identification certain. Loss through net heavy. Occurrence very rare in small numbers. Recorded twice at Station I, once at Station II.

Synura uvella Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	6,415	30	4,462	5,222	....

Identification uncertain. Colonies only counted. Loss through net probably very heavy. Occurrence greatest at Station I but at wide intervals there. Numbers recorded usually rather small. From our records it seems to do best at about 20° C. Maximum at Station I in August. Also evidently favored by sewage and stagnation, since it is recorded only once at Station II and five times at Station III. Certainly much less important than in Illinois, even with full allowance for escape through the net.

Trachelomonas euchlora Lemm.

	Station I	Station II	Station III	Daily	Hourly
Average	14,295	21,739	30,180	7,032	56,965

Identification uncertain. Small percentage retained by net. Found frequently in first half year at all stations. Rare in second half year. Warmer waters, sewage and stagnation seem to be deterrent, since numbers were smallest at Station I and during the period from June to October.

Trachelomonas volgensis Lemm.

Identification probable. Loss through net very heavy. Recorded five times near last of year at Station II and six times at Station III.

Trachelomonas volvocina Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	268,091	134,297	180,692	179,473	512,684

Identification uncertain. Loss through net very heavy. Recorded in every month at all stations. Maximum at Station I on August 20, at Station II on September 13, and at Station III on August 31. While a number of minor pulses are readily distinguishable at all stations, the percentage of loss is too uncertain to encourage conclusions. The maxima of the three stations coming so close together lead to the idea that temperature is an important factor for this form and that it does best above 20° C. The difference in averages listed above supports the view that sewage is beneficial and this is strengthened by the fact that several catches at Station I exceed the maxima at Station II and III. Stagnation seems favorable at all stations.

Volvox aureus Ehrbg.

Identification satisfactory. Recorded only at Station II, five times in August and September.

Volvox globator L.

Identification satisfactory. Recorded only at Station III twice, in September and December.

The following forms of Mastigophora were recorded only once or twice, or else they were thought to be present in fresh material:

Anthophysa sp. Once, I and Daily.
Chilomonas paramoecium Ehrbg.
Dinema sp. Once, III.
Diplosiga sp. All stations. Not counted because too small.
Diplosigopsis entzi France. Once, II.
Euglena acutissima Lemm.
Gonium pectorale O. F. M. Once, II and III and Hourly.

Gymnodinium sp.
Hyalobryon sp.
Mastigamoeba sp. Once, Station I, Station II and Hourly.
Oikomonas sp. Once, Station I.
Phacus longicauda Duj. Station I.
Salpingoeca sp.
Syncrypta sp. Once, Station II and III.
Uroglena volvox. Once, Station III and Hourly.

Rhizopoda

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	13	14	17	7	9
Average number of individuals per cubic meter	167,328	150,817	288,365	101,802	396,950

Rhizopoda, according to our records are from five to ten times as numerous as in Illinois. This is probably erroneous, however, since *Difflugia* contributes mainly to this showing and the *Difflugia* count includes an unknown percentage of *Tintinnidium*. Conceding this error to be very large, it still seems safe to say that the Rhizopoda were at least as important as in Illinois where Kofoid (1908) gives them a high rank because they are bottom living forms, actually present in far greater numbers than the catch of floating forms could possibly indicate. This adventitious character is just as strongly marked here as there, since all the recorded forms are irregular in distribution and erratic in occurrence. The group as a whole contributes most during the warmer season. This might be expected as a result of greater activity of the animals rendering them more liable to dislodgment. Larger numbers produced would also mean larger numbers dislodged. Heavy food supply would also account for it in part because, as Kofoid (1908) says, it means greater oil and gas production in the body of the animal thus reducing the specific gravity.

DISCUSSION OF SPECIES

Amoeba proteus Rösel.

	Station I	Station II	Station III	Daily	Hourly
Average	2,782	14,487	3,645	206	61,034

Identification uncertain. Probably includes several species. *Amoeba proteus* was the large form most frequently observed and so the name is used as being probably most frequently correct. Occurrence rather irregular at all seasons of the year. All stations agree in showing the largest numbers at about the height of the warm season, i.e., in August at Stations I and II and September at Station III. All show only very small numbers in cold weather. Larger numbers at Station

II may be due not so much to favorable effect of clean water as to the slight flow in the river tending to greater dislodgment.

Amoeba radiosa Duj.

	Station I	Station II	Station III	Daily	Hourly
Average	18,202	11,528	17,852	206	12,209

Identification satisfactory. Losses through net probably great. Although Kofoid (1908) counts *A. radiosa* with *A. proteus,* it is given separate listing here because it was the one form that seemed to be always clearly recognizable under conditions of counting. Either singly or combined the two forms were decidedly more numerous than the combination was in Illinois, and this is true of all stations. *A. radiosa* was not recorded at any station until the last of April. It developed a small pulse at Station I in May, disappeared entirely in July and August but reappeared in considerable strength in September. The maximum came in a strong abrupt pulse in late October after which the form disappeared again showing only two small records in the rest of the year. At Station II there were two occurrences in April and May, one (the maximum) in September and a small series of four records in October and November. At Station III there were scattered records from July to a September maximum, a small group in October and November and one catch in December. In spite of considerable differences at the three stations the record shows a rather definite preference for water a little below the maximum temperature. The larger numbers at Station I indicate a preference for sewage. An almost equal number at Station III warns against too much confidence in such a conclusion, however.

Arcella vulgaris Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	238	523	1,790	103	

Identification of species uncertain. Probably includes three or four species. Certainly there were marked differences in shells found. Not very important in our plankton so far as our records show. Occurred only seven times at widely separated intervals at Station I, four times in April and June at Station II, and six times at wide intervals at Station III. Numbers always rather small. Is known to be very abundant in ditches near Stockton. Clearly adventitious.

Cyphoderia ampulla Leidy.

Identification probable. Recorded five times at Station II, and four times at Station III in rather small numbers and at wide intervals. Clearly adventitious.

Difflugia corona Wallich.

Identification uncertain. Recorded three times at Station I, six times at Station II and twice at Station III, always in small numbers.

Difflugia pyriformis Py.

	Station I	Station II	Station III	Daily	Hourly
Average	76,692	51,957	43,846	71,508	28,483

Identification uncertain. Surely includes several other species certainly includes some *Codonella* and *Tintinnidium* which could not be readily distinguished while counting. This was especially true up to August before the presence of *Tintinnidium* and *Codonella* was noticed. In view of this error the record for *Difflugia* cannot be regarded as trustworthy. The variations in form are bewildering at best. As the record stands, the maximum seems to fall in June at all stations and Station I shows the largest numbers.

Hyalodiscus sp.

	Station I	Station II	Station III	Daily	Hourly
Average	26,286	15,566	22,818		144,447

Identification very doubtful. This form was not recorded until late in the season because it was small and hard to diagnose. It was finally decided to record it simply for the purpose of calling attention to considerable numbers of an organism frequently occurring which could not be definitely designated. The condition of the records does not warrant conclusions.

Microgromia socialis H. and L.

	Station I	Station II	Station III	Daily	Hourly
Average	23,280	56,487	72,004	15,976	61,034

Identification uncertain. Probably heavy loss through net. Occurrence at Station I in every month except January and December. Found mainly at the other stations in July, August, September and October. Evidently favored by warm weather and deterred by sewage.

The following forms were recorded only once or twice, or were thought to be present in fresh material:

Amoeba verrucosa Ehrbg. Once, II and III.
Difflugia acuminata Ehrbg. Once, II and III.
Difflugia globulosa Duj. Once, I and twice at III.
Euglypha alveolata Duj.
Hyalosphenia cuneata St. Twice, I.
Hyalosphenia papilio Leidy. Twice, I, once, II and III.
Nebela collaris Leidy. Once, III.
Pseudodifflugia gracilis Schlumbg. Once, III.
Quadrula symmetrica F. E. Sch. Once, III and daily.
Trinema enchelys Ehrbg. Once, III.

Heliozoa

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	8	6	10	4	4
Individuals per cu. meter..	370,995	257,232	274,580	619,156	441,478

While there were only a few species of Heliozoa recorded the numbers of some of the smaller forms were quite large and so make the group somewhat important. The extreme fragility under manipulation makes detailed examination somewhat untrustworthy in results and also invalidates the count more than in the other groups. Nevertheless the following records seem to be fairly satisfactory. Through some error in copying early lists, *Nuclearia* and *Vampyrella* were included with Rhizopoda. The numbers do not seriously change the totals in the two groups, however; the totals for Heliozoa have been left short by that much and the totals for Rhizopods show a corresponding excess.

DISCUSSION OF SPECIES

Heterophrys fockei Arch.

	Station I	Station II	Station III	Daily	Hourly
Average	24,459	139,328	98,532	55,170	207,538

Identification uncertain. May include other species or other genera at times. Thought to be usually correct. Not recorded at any station before July. Not present at any after October. One of the most definitely limited organisms on our records. Limited to a period of about sixteen weeks with a peculiar break in the middle (last of August). This is a period in which the temperature was almost constantly above 20° C. Maximum numbers on August 2 at Station I, October 4, at Stations II and III. Smaller numbers at Station I indicate deterrent action of sewage.

Heterophrys sp.

Probably not deserving separate listing though this fact was not discovered until too late to change easily.

Nuclearia simplex Cienk.

	Station I	Station II	Station III	Daily	Hourly
Average	7,020	338	15,871	206	44,758

Identification uncertain. No records until late in the season, partly because overlooked until October, partly because of indecision as to advisability of recording. It was finally decided that some indication of the presence of an organism possibly belonging under this species name was desirable. No conclusions can safely be drawn as to distribution, however.

Raphidiophrys elegans H. & L.

	Station I	Station II	Station III	Daily	Hourly
Average	309,635	79,467	107,739	532,371	20,345

Identification probable. First recorded in April at Station I and Station III, in March at Station II. Constant in occurrence at Station I through June, July, August and November. Irregular at other times. Irregular at both the other stations except for a period through August and early September at Station II, late June and July at Station III. Evidently favored by higher temperatures and sewage, not so much by stagnation. From these records, seems to be a rather important constituent of our plankton. This is somewhat different from the condition at Illinois where it appeared only as a constituent of back waters.

The following forms were recorded only once or twice or were thought to be present in living material.

Actinosphaerium eichornii Ehrbg. Once, I and III.
Diplocystis sp.
Vampyrella sp. Once, III.

Ciliata

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	32	22	25	9	10
Number of individuals per cubic meter...	946,762	447,909	431,445	1,306,075	3,136,583

Identification of ciliates was about as unsatisfactory as was that of the Rhizopoda and Heliozoa. This was due partly to distortion of preserved specimens and partly to small size. It is probable, however, that totals for the group are fairly accurate.

Members of the group were always found throughout the year, except for the first three and two collections at the first of the year at Stations II and III respectively. Unfortunately no general conclusions can be stated with full confidence from the totals of Protozoa because *Vorticella* sp. is too largely responsible for them. This was because *Vorticella* sp. was used as a sort of catchall for a miscellaneous assemblage of organisms which could not be readily distinguished under conditions of counting. Most of these were clearly *Vorticella* (nearly all of the short stem type) but some craspemonad flagellates and the like were undoubtedly counted in at times. In spite of these defects in the record, there is some reason for thinking that the group as a whole develops best in sewage water and in the higher temperatures with rather stable conditions. Since this does not agree very well with Kofoid's (1908) Illinois results and since the net error is undoubtedly great, too much importance must not be attached to such a suggestion.

Whatever the truth may be concerning their distribution there is no question that the Ciliata exert a very marked influence amongst local planktonts, especially in Stockton Channel. The larger Ciliata are quite conspicuous in the catches there in the colder months.

DISCUSSION OF SPECIES

Askenasia elegans Bloch.

Identification probable. Recorded only at Station I four times in small numbers. Thought to have been positively recognized in fresh material, however.

Chilodon sp.

Identification doubtful. Recorded four times at Station I and twice at Station II in small numbers.

Coleps hirtus Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	7,338	3,052	4,149		

Identification certain. Loss through net heavy. Probably also overlooked in counting sometimes. Recorded ten times at Station I, five of which came in December. Recorded twice at Station II and once at Station III. Evidently favored by sewage and probably by temperature below 15° C.

Colpoda sp.

Identification very doubtful. Recorded at Station I five times in very small numbers, once at Stations II and III.

Cyclidium sp.

	Station I	Station II	Station III	Daily	Hourly
Average	29,530	10,234	6,286		24,414

Identification unsatisfactory. Referred to this genus purely on general resemblance to figures in reference books. No undulating membrane was visible under conditions of counting. Apparently a warm water form favored by sewage. Small percentage retained by net.

Didinium nasutum.

Average at Station I, 1,636.

Identification positive. Recorded sixteen times at Station I at irregular intervals January to April and in November. Only once at Station II and twice at Station III. Distinctly a cold water form. Probably heavy loss through net.

Euplotes patella Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	38,100	7,350	8,068	....	....

Identification of species fairly certain. Recorded in first three and four months and the last two months at all stations. Far more numerous at Station I. Distinctly favored by sewage and low temperatures. Spring maximum on March 19 at Station I at 14.5° C. Fall maximum on November 12, at 17.5° C. Disappearance in April at 20° C., reappearance in October at 19° C.

Euplotes sp.

Average at Station I, 3,567.

Recorded only twelve times at Station I (February 8–April 5), twice at Station II and three times at Station III. Showed same tendencies of distribution as preceding species. Probably variety of same.

Halteria grandinella O. F. Müll.

	Station I	Station II	Station III	Daily	Hourly
Average	3,390	....	126	206	12,207

Identification probable. Loss through net heavy. Recorded sixteen times in first three months and five times in the last three months at Station I, only five times at Station III. Apparently adventitious and not of much consequence here.

Hastatella radians Erlanger.

	Station I	Station II	Station III	Daily	Hourly
Average	2,245	32	96	....	....

Identification positive. Probably very small percentage retained by net. Recorded fourteen times at Station I, once at Station II and twice at Station III, in February, March, April and December. Distinctly a cold water form and almost as distinctly favored by sewage. Notwithstanding its small size this form is so distinct in appearance and so little deformed by preservation that the count is unusually trustworthy.

Holophrya sp.

	Station I	Station II	Station III	Daily	Hourly
Average	109,113	76,816	103,778	140,641	870,497

Identification very doubtful. This generic name was used as a catchall for a number of forms that might be referred to it without too great stretch of possibilities. They were usually too much deformed in preservation to give any definite clue to affinities. About all that can be safely said is that the assemblage is favored by warmer waters and stagnation, probably also by sewage.

Paramoecium aurelia O. F. Müll.

	Station I	Station II	Station III	Daily	Hourly
Average	10,931	1,415	941	....	....

Identification satisfactory. Loss through net probably heavy. Occurrence almost entirely limited to first two and last two months of the year. Hence distinctly a cold water form. Record at Station I fairly constant in periods mentioned, with a maximum in December. Numbers small and catches rare at Station II and III. Evidently does best in sewage, probably on account of quantities of bacteria for food.

Paramoecium bursaria Focke.

	Station I	Station II	Station III	Daily	Hourly
Average	9,785	4,254	439	....	....

Identification uncertain. Probably should be included with *P. aurelia* though there seemed to be some difference. Shows practically same characteristics of distribution as the former species.

Paramoecium caudatum Ehrbg.

Identification satisfactory. Although a few specimens of this type were found six times at Station I and once at Station III, it was probably not worth while to attempt separation. They are too few to signify much.

Pleuronema sp.

	Station I	Station II	Station III	Daily	Hourly
Average	5,402	3,052	16	....	....

Identification doubtful. Recorded thus as nearest possibility. Records indicate preference for sewage and cold water.

Prorodon sp.

	Station I	Station II	Station III	Daily	Hourly
Average	7,379	677	4,243	206	492

Identification uncertain. Occurrence almost entirely confined to first three months and last three months of the year, thus indicating the favorable influence of cold weather. Larger numbers at Station I were probably due to sewage.

Stentor coeruleus Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	8,141	123	141		492

Identification usually satisfactory. Under conditions of counting probably some confusion with *S. niger* and perhaps another species. This was because distortion in preservation made it almost impossible to use any distinction except size in many cases, hence a small *S. coeruleus* might be mistaken for *S. niger*, or a large specimen of the latter might be mistaken for the former. Generally, however, the stouter body of *S. coeruleus* showed plainly enough to make it fairly certain. Occurrence was almost confined to first four months and December. Only two catches were recorded at Station II and three at Station III. Clearly a cold water form almost limited to sewage or at least to water with heavy organic content. Maximum occurred in December at Station I, although the catches were fairly constant over a period of four months from the first of the year. The maximum for this early period was in January. Since it is absent at periods of greatest stagnation, this planktont is evidently more influenced by temperature than by that factor. The most favorable temperature seems to be at about 10° C. since the maxima just mentioned come at about that condition.

Stentor niger Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	42,691	739	871		472

Identification satisfactory. Probably some loss through net. Also considerable loss of this and the preceding form through clinging to net, utensils, etc. This form was first recorded as *S. roeselii* on account of the nucleus, but the delicacy and grace of form together with smoky color seem so strongly characteristic that it has finally been referred to *S. niger*. The decision to make the change was mainly due to Professor Kofoid's statement that nuclear characters are very unstable in this genus. They cannot be determined at least while counting.

Occurrence at Station I runs later in spring and begins earlier in fall than that of *S. coeruleus*. The numbers are very noticeably greater in the fresh material while the animals are active. The January and December maxima fall on the same dates as those of *S. coeruleus* but there are strong pulses in April and May by way of contrast. It seems safe to say then that both species have about the same optimum but that *S. niger* is able to endure a slightly higher temperature (20° C.) and that it is less disturbed by flood conditions.

Tintinnidium fluviatile St.

	Station I	Station II	Station III	Daily	Hourly
Average	17,333	3,359	8,642	7,341	323,479

Identification uncertain. Loss through net probably heavy. For some reason (probably because intent on *Difflugia*) the writer entirely overlooked this form and that of *Codonella* until attention was forcibly attracted by some living material in 1914. This was after the count had progressed almost through the first seven months of 1913, hence it was too late to rectify by recounting. It was also impossible at that late date to distinguish the three forms readily in preserved material. Undoubtedly some *Codonella* and a few *Difflugia* are included under the present head. It is also probable that *Difflugia* includes some of both *Tintinnidium* and *Codonella* even after an attempt was made to differentiate them. *Codonella* was not successfully distinguished at all. The count as it stands yields very imperfect results. It appears certain, however, that *Tintinnidium* does best in heavy sewage. Since the river shows least of this species it is also probable that quiet water is favorable. So far as the evidence goes, it seems that higher temperatures are best.

Trichodina pediculus Ehrbg.

Average at Station I, 631.

Identification probable. Loss through net probably heavy. Occurrence at Station I almost entirely in first three and last three months. Recorded only once at Stations II and III. Small numbers everywhere. Surely a cold water form favored by sewage. Adventitious.

Vorticella longifilum Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	13,991	2,588	3,612	413	....

Identification doubtful. Count includes all individuals with very long and slender stalks. None were ever found attached to anything. Loss through net probably very heavy. Occurrence at Station I mainly in last three months. Catches in small numbers and at widely separated and irregular intervals at other times and other stations. Evidently a cold water form doing best in sewage and quiet waters.

Vorticella sp.

	Station I	Station II	Station III	Daily	Hourly
Average	623,067	274,328	300,528	1,153,087	1,797,514

Identification uncertain. Probably includes several species of short stemmed *Vorticella* and some craspemonad flagellates attached to various objects.

Those taken to be most typical of this miscellaneous assemblage were found on the bodies and appendages of Entomostraca, especially Cyclops. Most of these were large enough to be fairly accurately counted. In view of the miscellaneous character of the forms included, it is undesirable to draw definite conclusions. There is, however, a clear suggestion of preference for sewage and quiet water. Higher temperatures are also distinctly favorable for the assemblage and this is in marked contrast to nearly all the other ciliates.

The following forms were recorded only once or twice or else were thought to be observed in fresh material.

Aspidisca sp.
Bursaria sp. Twice I, once, III.
Carchesium sp.
Climacostomum virens St.
Condylostoma vorticella Ehrbg.
Didinium balbianii Btschli.
Enchelys sp. Twice, I, once, III.
Epistylis sp. Twice, II.
Frontonia sp. Twice, I, once, III.
Gastrostyla sp.
Glaucoma sp. Once, I.
Lacrymaria sp.
Loxophyllum sp. Twice, I.
Mesodinium acarus St.
Pyxidium cothurnoides Kent.
Rhabdostyla brevipes Cl. & L. Once, I.
Spirostomum sp.
Trachelius ovum Ehrbg. Twice, I.
Urocentrum turbo Ehrbg.

Suctoria

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	3	3	3	....	1
Number of individuals per cubic meter	762	8,995	8,039	....	1,969

Only three forms were recorded from this group and they occurred at all three stations but mainly in the last three or four months of the year. In no case were the numbers very large. While genera could not be identified with much confidence, it yet seemed clear that the forms recorded were Suctoria and that the generic designation was probable. Inasmuch as none of the three forms appeared to be a true planktont and the numbers were few, it seems hardly necessary to attempt detailed discussion. The most notable suggestion that can be made is that sewage seems unfavorable to all three forms. The following are the three forms recorded. See tables 1–5.

Acineta sp.
Podophrya sp.
Sphaerophrya sp.

ROTIFERA

Plates 3–6 and 15–17.

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded..	55	43	39	30	34
Individuals per cu. meter..	4,842,320	883,510	1,302,609	5,443,643	5,681,372
	Eggs 31%	Eggs 45%	Eggs 34%	Eggs 29%	Eggs 34%

These averages are made from records which include males, females, eggs attached, a few records of free eggs, winter eggs, male eggs and parasitized individuals. Further distinctions were not advisable because of inability to carry them through the count with accuracy.

Rotifera were found in every collection through the whole year at all stations. Only twice in the whole year did the numbers fall below 75,000 per cubic meter at Stations II and III, and at no time was a smaller number than 200,000 recorded at Station I. This makes a remarkably consistent showing, especially by way of contrast with Illinois conditions as found by Kofoid (1908). This consistency is even more striking than are the distinctly larger numbers found here at all stations. Both features are evidently due to the peculiar climatic conditions of this region. There is agreement with Illinois records in the fact that minimum production occurred in winter and the maximum in warmer weather, though much later there than at Station I. There is a difference in that the fluctuations were less extreme here, and that maxima occurred in November at Stations II and III.

Recurrent pulses were fairly well marked at all stations though the intervals were quite variable. These pulses were not coincident with those of any other group. The maximum number of Rotifera did not correspond in time with the maximum mass production of plankton at any station nor did it agree with any other group.

This group affords another illustration of a case in which a single genus exerts a remarkable influence on the whole group, the late maximum in November at Stations II and III being due to *Keratella*. Since, however, this same genus is largely responsible for throwing the Illinois maximum into May, perhaps those records and ours can be compared with some fairness.

Catches of 1,000,000 or near that number were rare at temperatures below 15° C. About eighty-seven forms of Rotifera were listed.

The names used have been checked as closely as possible to correspond with those indicated in Harring's *Synopsis of the Rotatoria*.

Rhizota

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	2	3	3	....	3
Individuals per cu. meter..	1,509	37,181	30,185	....	16,145

Practically all of the Rhizota found at any station were single individuals without tubes. Only two or three times were colonial forms recorded and then only part of the colony was present. These facts serve to emphasize the adventitious character of the Rhizota and to indicate that their presence in the plankton was due to broken anchorage. The large numbers at Stations II and III as compared with Station I suggest a decidedly deterrent influence of sewage.

DISCUSSION OF SPECIES

Collotheca pelagica Rous.

	Station I	Station II	Station III	Daily	Hourly
Average	1,325	21,747	7,629	....	1,477

Identification uncertain. May include two or three species, one of which is possibly *C. mutabilis*. The preserved condition does not permit of very accurate judgment and the animals were usually without tubes. So many of the tubes which were seen were of a slender type that it was thought that they indicated the species designated. This form was only recorded at Station I six times (in small numbers), all in August, September and October with the largest number in October. Occurrence at Station II was from August 15 to November 22. Most of the catches were fairly large and there were only two failures to appear in that period. The largest number recorded was in August, due probably to some unusual disturbance of the water by barges or dredges.

Attached eggs of this genus and almost entirely of this form were recorded with averages as follows: Station I, 185; Station II, 14.288; Station III, 15,332. Although certainly adventitious, the combined numbers of eggs and adults make this form of some importance in the local river plankton for a brief period. It is not adapted to life in sewage, however.

The following forms were recorded only once or twice or were thought to be present in fresh material:

Collotheca ornata Ehrbg. Once, I and III.
Conochiloides dossuarius Hudson.
Conochiloides natans Seligo.
Conochilus hippocrepis Schrank.
Conochilus unicornis Rous. Once, II and III.
Cupelopagis vorax Leidy. Once, III.
Ptygura brevis Rous.

Bdelloida

	Station I	Station II	Station III	Daily	Hourly
Number of forms recorded	6	6	3	3	2
Individuals per cu. meter..	349,312	47,105	56,806	120,831	225,414

These large averages are perhaps unfair, inasmuch as they are largely influenced by the assemblage of unidentified forms which was assigned to the Bdelloida because it seemed almost certain that all but a very few belonged to that group.

The only genus recorded is *Rotaria* and it is itself a heavy contributor to the plankton. Probably some other genera are included, especially in the unidentified list. The larger numbers at Station I indicate a distinct preference for sewage, a condition directly opposite to that of the Rhizota. The representation in February and March at Station I is much heavier than at any other time of year, the maximum falling on March 12. This is very largely due to the abundance of *Rotaria rotatoria.* The maxima at Stations II and III came in October and August respectively, due to the greater influence of the unidentified assemblage at those stations. It must be acknowledged that the data for this group do not lead to satisfactory conclusions. Some of the difficulty is due to the characteristics of the group and some to the difficulty of identification in preserved material.

DISCUSSION OF SPECIES

Rotaria neptunia Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	14,987	2,331	3,829	1,961	492

Identification usually positive. Occurrence most constant in cooler months of the year at all stations. Much more abundant at Station I, thus showing preference for sewage. Not recorded in April, May and June at Station I and but rarely in July and September. Numbers small in March, species well represented in other months. Maximum number recorded twice, October 15 and November 5 at temperature of 18.5° C., which is probably near the optimum. Small numbers in early January were probably due to the temperature being below 10° C. Flood conditions may be responsible for absence in April, May and June while high temperature accounts for it in July. The reason for absence in September after being recorded in August is not clear.

While definite pulses were present, there is not much regularity of appearance.

At Station II this form was recorded in every month except February, April, May and June though the numbers were rather small throughout and the catches mostly at irregular intervals. The maximum occurred in October at a temperature of 20° C. and again at 17° C. Conditions were much the same at Station III except that April, June and July were the only months without catches. This again supports the conclusion that flood and higher temperatures are both deterrent factors. The maximum came in October.

While the habits of this organism would lead one to think of it as really adventitious in the plankton, the large numbers here raise a definite question as to the validity of that view. Can it be that this animal has adopted a free swimming habit under our local conditions? Or are the general conditions so favorable for development that favorite haunts become rapidly overcrowded thus forcing individuals temporarily into the plankton while seeking other quarters?

Rotaria rotatoria Pallas.

	Station I	Station II	Station III	Daily	Hourly
Average	287,186	19,099	18,283	54,197	8,500

Identification uncertain. Probably includes two or three other species and possibly other genera. So far as estimated from living material the above named species was more numerous; the others could not be distinguished from it while counting. Occurrence in every month of the year at all stations, though rather light in April, May and first half of June at each, and continuing so through June and July at Stations II and III. The maximum came in March at all three stations. The fairly rapid decline after the March maximum was apparently due to the incoming mountain flood waters. There was a marked pulse in July at the disappearance of these flood waters. Higher temperatures undoubtedly kept the numbers down, however, and none of the pulses of the last half year reached the numbers common in the first quarter year. This, of course, is also some indication that the comparative stagnation of the last half year was less favorable than the disturbed hydrographic conditions of the first three months when there was enough rainfall to cause considerable local variation. Comparison with the 1914 condition when there was heavier rainfall may help to settle some of these questions. The numbers clearly show that this form does best in sewage. There can be no question that it prefers temperatures below 20° C. and the indications are that it does best in waters slightly disturbed, as by local rains, but this cannot be settled now.

No other forms of Bdelloida were recorded.

Anuraeopsis sp.

	Station I	Station II	Station III	Daily	Hourly
Average	8,230	308	4,619	....	26,867

Identification doubtful. Record probably includes two or three small forms with indistinct characteristics in the preserved condition. Referred to this genus as the nearest probability. May include distorted specimens of *A. fissa*. Since the only records of this form are in June and July at the three stations, it may be that the whole number should be transferred to *A. fissa*.

Asplanchna brightwelli Gosse.

	Station I	Station II	Station III	Daily	Hourly
Average	16,892	308	533	43,192	2,954

Species determination uncertain. Genus certain. Record probably includes at least two or three species under this heading, species segregation being too difficult during the count. Eggs not counted.

Occurrence at Station I regular from mid-March to November I. Maximum, 158,688, on July 5 but almost equalled in April and October. Recorded only three times at Station II in April, June and July in small numbers. Recorded five times at Station III from March to November in small numbers and at wide intervals. Distinctly favored by sewage and by temperatures near 20° C.

The record at Station I shows ten fairly distinct pulses, seven of which followed pulses of chlorophyll bearing organisms by from three to seven days, two of which coincided with such pulses, while one preceded. The correlation of these pulses is far the most impressive of any yet observed. The following table, text table 3, shows temperatures and pulses:

TEXT TABLE 3

April 9	18	132,240	April 26	20	41,600
May 11	21	44,800	May 27	23	51,200
June 7	25	44.800	July 5	26	158,688
Aug. 2	26	44,800	Aug. 15	23.5	76,800
Sept 13	25	51,200	Oct. 29	19	105,792

Asplanchnopus sp.

Identification doubtful. Recorded three times each at Stations I and II and six times in hourly series at Station III. Not important.

Brachionus.

Identification of the females of this genus was nearly always satisfactory as to genus but the separation of species was frequently difficult and sometimes impossible. Males were never positively recognized, hence species records were of females only. Eggs were easily identified when attached but the confusion was great when unattached. Probably eggs of other genera were often included amongst the free eggs. Eggs of species were not recorded.

Only seven species and one variety were recorded, although there were probably many more. The reference of many individuals to some of these species was somewhat arbitrary, but on the whole the eight groups were fairly definite in the writer's mind and may be properly discussed despite some technical error in identifying.

Since the eggs were only recorded for the genus as a whole their averages and the main features of their occurrence may be stated now.

TEXT TABLE 4

	Station I	Station II	Station III	Daily	Hourly
Av. female eggs attached	255,960	16,390	28,607	409,180	132,240
Av. male eggs attached..	26,190	2,773	4,443	4,238	22,806
Av. female eggs free......	351,039	14,780	41,963	718,362	396,720
Av. male eggs free	817	....	157	....	....

In view of the uncertainty of identification of unattached *Brachionus* eggs either male or female, it is hardly worth while to attempt any detailed discussion of the records for these kinds. The maximum for both kinds of attached eggs came early in March at Station I. Occurrence of attached male eggs was scattered after March, though the female eggs were almost constantly present through the year. They almost reached the March maximum twice in September. At Station II there were only three records of male eggs, two coming in March. Occurrence of female eggs was fairly constant from June to October inclusive, infrequent at other times, the maximum coming in October. At Station III male eggs were recorded seven times, the maximum in March. The female eggs occurred rather regularly from February to October inclusive, excepting April, when there were none. The maximum came on October 4. About the only safe conclusion to be drawn from these inadequate records is that male eggs are most numerous in early springtime at all stations. It is, of course, unfortunate that the attached eggs were not segregated with the proper species, but the desirability of segregation was not realized until too late in the count.

Brachionus angularis Gosse.

	Station I	Station II	Station III	Daily	Hourly
Average	78,367	3,417	4,675	14,579	8,630

Identification usually satisfactory. Occurrence far most conspicuous in May and June at Station I, with maximum in mid-May. Missing in January, February, and December, rare in March, April, July, August and October. Occurrence at Station II from April to November inclusive, but scattered and in small numbers with a maximum in September. Limited to same period at Station III but regularly recorded during most of May and June with maximum in May, favored by sewage and by a temperature near 20° C. Stagnation seems to be detrimental.

The periods of regular occurrence were too short to give very well marked evidence of recurrent pulses.

Brachionus angularis caudatus B. and Da.

	Station I	Station II	Station III	Daily	Hourly
Average	323,532	65,243	70,480	830,657	1,284,905

Identification usually satisfactory. Sometimes hard to distinguish from type form of *B. angularis*. The separate record of this variety seems to have been worth while because of the tremendous emphasis which it gives to the continuity in occurrence of the two forms. The variety was almost wholly absent from the collections until the type form had passed the spring maximum. As the latter declined the former increased until it entirely displaced the other. This was strikingly true at all three stations. The variety also disappeared by November at all stations, at which time the type came in in small numbers for a few weeks. At Station I the maximum came on June 25 but was almost equalled in September. At both of the other stations the maxima came in August.

Recurrent pulses were very marked in the records for this form as shown by the following table:

TEXT TABLE 5

Station I	Station II	Station III
June 7		
June 25		
July 12	July 12	July 12
July 26		
Aug. 20	Aug. 15	Aug. 2
Sept. 9	Sept. 20	Aug. 31
Sept. 27		
	Oct. 11	Oct. 18

Comparison with the table of ploiman pulses at Station I shows that four of the *B. caudatus* pulses correspond exactly while two others are very close. It is thus evident that the relationship of occurrence of this organism to that of the chlorophyll bearers is about as intimate as that of the whole ploiman group.

The larger numbers at Station I indicate favorable influence of sewage and the distinct limitation to temperatures above 20° C. and mark *B. caudatus* as a summer form. The maxima in late summer may also indicate stagnation as a favorable factor. Kofoid's reference (1908) to the contention of various observers that spinous processes, etc., appear as adaptive responses to lessened buoyancy of warmer waters is especially interesting in this connection. The condition of our records more strongly supports that view than do the Illinois records. In fact the evidence could hardly be stronger without deliberate manipulation.

Brachionus budapestinensis D.

	Station I	Station II	Station III	Daily	Hourly
Average	970	7,564	2,322	413	9,615

Identification doubtful. Recorded six times at Station I, thirteen times at Station II and seven times at Station III. Occurrence at all stations rather scattered and mainly from July to October. Maximum at Station II in August. Apparently hindered by sewage but favored by warmth and stagnation. Not a very important form here, though the average at Station I is somewhat higher than it was in Illinois.

Brachionus calyciflorus Pallas. . (B. pala Ehrbg.)

	Station I	Station II	Station III	Daily	Hourly
Average	109,718	10,828	32,378	516	175,708

Identification satisfactory. No attempt to distinguish varieties in final records. The above count consists entirely of females exclusive of eggs. The most striking features in the record of the occurrence of this form are its great abundance in the first four or five months of the year at all stations, its abrupt disappearance at the close of this period and its reappearance in considerable numbers in and after August. The three stations vary considerably in these last two points, the break in the record in May being much more abrupt at Station I than at either of the others. Station I also shows only a few very light catches in the fall while Station III reaches the maximum for the year at that time. Station II has the maximum in February but shows records of considerable numbers through September and October. Station I has the maximum in March. The reasonable inference seems to be that much sewage is favorable to this species in flood water but that it is detrimental in stagnation. Also that temperatures above 20° C. are rather unfavorable.

The numbers here were much larger than those noted in Illinois and the vernal maxima came about a month earlier. Otherwise there is rather close similarity in the records. Recurrent pulses are not distinct, however, at any of our stations here.

Brachionus capsuliflorus Pallas. *(B. bakeri* Ehrbg.)

	Station I	Station II	Station III	Daily	Hourly
Average	1,954	14,418	9,582	1,445	40,468

Identification probable. Occurrence at Station I scattered, in small numbers, from May to December, with a small maximum in October. Occurrence at Station II almost limited to August and September, with a maximum in September. At Station III somewhat similar, except for a slightly larger number of earlier records of small numbers.

The likeness to Illinois conditions is very marked, especially at Station II. Our records indicate that sewage is detrimental while stagnation and rather high temperature (near 24° C.) are beneficial. It seems rather strange that though the river showed the largest numbers, the limits of their occurrence were much more sharply defined than at the other stations; only four small catches being found outside of the eleven weeks period from August 2 to October 11, as against twice that number elsewhere. No males were recognized.

Brachionus patulus Müll. *(B. militaris* Ehrbg.)

	Station I	Station II	Station III	Daily	Hourly
Average	120	4,804	1,631	310	10,469

Identification certain. Recorded only once at Station I in July (6,400). Occurrence at Stations II and III limited to July and August and September, except for one catch on December 6 at Station II. Maximum on September 6 at both places. Evidently a summer form favored by stagnation but intolerant of sewage. No data are at hand bearing upon Kofoid's suggestion (1908) that this species probably thrives in warm, shallow water rich in organic matter. Its absence from sewage does not prove that it would be injured by decaying vegetation, etc.

Brachionus plicatilis Müll. *(B. mülleri* Ehrbg.)

	Station I	Station II	Station III	Daily	Hourly
Average	9,179	977	965	413	....

Identification usually satisfactory. Occurrence at Station I mainly in first three months, thereafter in small numbers at variable but usually wide intervals through the year. Maximum (132,240) twice, February 12 and March 5. Numbers always small at other stations, otherwise distributed about the same. Hence this form may be said to be definitely limited to temperatures below 20° C. Sewage appears to be favorable.

This species is not listed by Kofoid for Illinois. Mr. H. K. Harring designates it particularly as a brackish water form. It is also so listed in *Süsswasserfauna Deutschlands*. However, its presence here is not so prominent as is that of the brackish water diatom, *Bacillaria paradoxa*. Some other factor than salinity must determine the occurrence of such forms.

Brachionus urceus L.

	Station I	Station II	Station III	Daily	Hourly
Average	139,352	8,558	2,871	352,237	36,606

Identification usually satisfactory. Some confusion with other forms at times. Recorded in every month of the year at Station I. Missing in March and November at Station II, in April, November and December at Station III. There was a well developed pulse in February at Station I but there were only four catches from March 1 to May 14 when a long period of regular appearance in considerable numbers began, which finally ended on October 29. Numbers were then small and absences frequent to the end of the year. Maximum (899,232) reached twice in June. Records scattering at Station II except in June, July and August. Maximum (105,792) on August 2. Conditions similar at Station III with smaller numbers. Maximum September 20, 38,400. This form shows a clear preference for sewage and for temperatures above 20° C., but stagnation is apparently detrimental. Recurrent pulses are fairly distinct at Station I as follows:

Feb. 8
June 3
June 21
July 12
July 26
Aug. 9
Aug. 23
Sept. 9
Sept. 27
Oct. 15
Oct. 29
Nov. 15

Of the twelve dates just mentioned, eleven can be connected definitely with pulses of chlorophyll bearers, four preceding by from four to eleven days, four following by three or four days and three exactly coinciding.

Brachionus with endoparasites. Average at Station I, 5,363.

Different species of *Brachionus* were found infested with parasites but no specific count was made. These parasites were rather small and their relationships were not determined. In almost all cases they occupied at least half of the space inside the lorica of the host. None were noticed at Stations II and III so it is probable that sewage is favorable to the parasites in some way. They were recorded five times at Station I, one in June, thrice in August and once in November.

Diurella egg, free.

	Station I	Station II	Station III	Daily	Hourly
Average	4,161	146,079	108,270	4,445	122,068

Identification very doubtful. Small eggs attached to filaments of *Melosira granulata* were counted under this heading. They were only recorded eight times at Station I but they were quite prominent at the other stations, at Station II from June to October inclusive, at Station III from May to October inclusive. Inasmuch as no considerable number of *Diurella* females were ever found, it is probable that these eggs were wrongly designated, but nothing is known as to the real identity.

Epiphanes clavulata Ehrbg. (Notommata.)

	Station I	Station II	Station III	Daily	Hourly
Average	1,263	6,400	10,423	....	....

Identification uncertain. Recorded five times at Station I, nine times at Station II and seven times at Station III in August, September and October. Hence it is to be regarded as definitely limited to stagnating waters and temperatures above 20° C. Sewage unfavorable. Attached female eggs were also recorded for this form at Stations II and III.

Filinia brachiata Rous. (Triarthra.)

	Station I	Station II	Station III	Daily	Hourly
Average	2,943	123	62	206	....

Identification certain. Recorded eleven times at Station I and once at each of the other stations. Occurrence at Station I usually in small numbers at rather wide intervals. Catches grouped in May and November. Maximum in November. This species was not reported as present in Illinois.

Filinia eggs, attached.

	Station I	Station II	Station III	Daily	Hourly
Female, average	79,131	554	1,004	12,667	....
Male, average	24,818	431	251	....	....

Identification certain. Attached female egg appeared in every catch at Station I from February 12 to April 26, then frequently to

July 19, being absent the rest of the year except for two small catches in November. Maximum (1,481,088) in March. Recorded only five times at other stations, mainly in March.

Male eggs were recorded continuously at Station I for a short time in February and March and there were occasional catches to June 28. They were recorded once at Station II and twice at Station III in small numbers. Both kinds were first recorded at Station I on February 2.

The maximum egg records of both kinds at Station I preceded the maximum record for females of *Filinia longiseta* by three days and the maximum for female eggs was almost reached again four days after it.

Unattached *Filinia* eggs were not certainly identified though recorded.

Filinia longiseta Ehrbg.

	Station I	Station II	Station III	Daily	Hourly
Average	361,166	14,486	12,192	99,012	4,561

Identification positive. About twice as abundant at Stations II and III as ever noted by Kofoid in Illinois and about fifty times as many at Station I. Seasonal limitation earlier and more definite here at all stations. Occurrence at Station I regular from January 5 to July 19, missing thereafter except for two small catches in December. Maximum on March 8, 6,083,040. Catches of more than 1,000,000 taken seven times in February and March, three in May and one each in June and July. An extremely important planktont at this station. At Station II one small catch was made in January but the regular occurrence began February 23, extending to April 13. Several more catches to July 12, then none till late October, followed by another in December. Maximum on March 8. At Station III one small catch came in January, then the regular occurrence began on February 8, extending with one lapse to July 12. Only two catches thereafter, one in July and one in October. Maximum on June 28.

There were rather distinct recurrent pulses at Station I culminating as follows:

Jan. 15
Jan. 29.
Feb. 12
Feb. 23
Mar. 8
Apr. 13
Apr. 26
May 7
June 3
July 5

Contrary to Illinois conditions the principal occurrence of this form was below a temperature of 20° C. instead of above, and from March to July instead of from May to October, so far as Station I is concerned. In view of the enormous numbers at Station I it may be safe to conclude that the food factor is more potent than temperature and that the smaller Illinois numbers at lower temperatures were only indirectly due to that condition. With abundant food in the sewage the lower temperatures seem quite favorable here. This form may then be regarded as very dependent upon sewage. The higher temperatures and stagnating waters seem to be deterrent.

Keratella cochlearis Gosse. (Anuraea.)

	Station I	Station II	Station III	Daily	Hourly
Average	78,769	281,504	354,304	164,517	6,530

Identification usually certain. No attempt to distinguish varieties. Some confusion probably of spineless varieties with spineless varieties of *K. quadrata* or other species. The numbers were greater at all stations than recorded for Illinois, but the records resemble Illinois records in the fact that the organism was found at some station in every month of the year. Also in the fact that there was a period of regular occurrence in the first seven months of the year, separated by a period of irregular occurrence or absence from a period of regular occurrence in the last three months. The location of the maximum is distinctly different from the Illinois condition at all stations. The maximum there was early in May, while our records show a maximum at Station I in July and at Stations II and III on November 1, the last two being in remarkably large numbers. The inference from our records is that sewage is detrimental in large amounts, that stagnation is even more so, and that temperature in moderate limits is less important directly than are other factors. The optimum temperature seems to be slightly below 20° C. The presence of largest numbers at Station III indicates the probability that a larger amount of organic matter than that in the river may be favorable.

Recurrent pulses are distinguishable at all stations, about half of those at Station I corresponding closely with those of chlorophyll bearers.

Station I		Station II	Station III
Feb. 12	June 18	Mar. 23	Mar. 23
Mar. 5	June 28	Apr. 19	Apr. 19
Mar. 19	July 5	July 12	May 31
Apr. 2	Oct. 26	Nov. 1	July 12
Apr. 23	Nov. 12		Nov. 1
May 7			

This was numerically the most important planktont at Stations II and III.

Keratella quadrata Müll. *(Anuraea aculeata.)*

	Station I	Station II	Station III	Daily	Hourly
Average	1,276,350	42,919	57,432	1,467,437	219,396

Identification usually certain. Contrary to Illinois records this was numerically our most important rotifer, all stations considered. It was one of the most important planktonts. Furthermore our records show it to be a distinctly perennial planktont here, since considerable numbers were found at all stations in every month of the year. At Station I there was only one lapse in the record. The increase was unusually uniform from January 5 to the maximum on June 28, followed by a similar decrease to December 31. At Station II the occurrence resembled that of *K. cochlearlis* in that there was a decrease in numbers with a few absences in the summer months, thus making the records for spring and autumn more prominent. The maximum came on October 18 not far from the *K. cochlearis* maximum. At Station III the records for the summer were not materially different from those for spring and fall except that the maximum came on October 11 in a much larger pulse than at other times.

Not only do our records fail to correspond with those of Illinois, they also fail to agree at our three stations. Consider, for example, the maximum in relation to temperature. Station I shows a maximum in a strongly developed pulse at a temperature of 23° C., Stations II and III at 17° C. Station I has its largest numbers in summer, Station II its smallest and Station III much the same as in other seasons. In spite of these differences some definite conclusions are possible. The vastly larger numbers at Station I at all seasons indicate not only a beneficial effect of sewage but the importance of the food factor. The smaller numbers at all stations in January and December show that temperatures may get low enough to be injurious, though it is not clear that this may not be due to reduced food supply incident to low temperature. In fact, when one considers that the numbers appearing at Station I at 7° C. or 9° C. were as large as those found in the culminations of ordinary pulses at the other stations in any season, it seems that the range of temperatures in ordinary fresh waters has little direct bearing on production. The unusually strong pulses in October at Stations II and III indicate a beneficial effect due to relief from Stagnation by the incoming autumnal freshet waters from the mountains.

Recurrent pulses are quite prominent in the records for this form, with culminations as follows:

Station I		Station II	Station III
Jan. 15	June 28	Feb. 8	Feb. 8
Jan. 29	July 12	Mar. 29	Mar. 23
Feb. 12	July 26	Apr. 19	Apr. 5
Feb. 23	Aug. 23	May 31	May 17
Mar. 8	Sept. 13	July 19	June 28
Apr. 5	Oct. 8	Aug. 31	July 26
Apr. 19	Dec. 3	Oct. 18	Oct. 11
May 11	Dec. 14	Nov. 30	Dec. 14
June 3	Dec. 31		

Keratella eggs, attached.

	Station I	Station II	Station III	Daily	Hourly
Average	263,312	54,732	96,442	140,815	12,669

Identification certain. No male eggs were recorded and no effort was made to keep the species record separate for eggs. The desirability of such separation was overlooked until too late; hence, as might be expected, the egg record shows the same characteristics as the dominant species, i.e., *K. quadrata* at Station I, and *K. cochlearis* at the other two stations.

Keratella egg, free.

	Station I	Station II	Station III	Daily	Hourly
Average	363,933	57,631	100,216	128,490	602,201

Identification quite uncertain. The designation was probably correct in a large majority of the counts but there is enough uncertainty to invalidate definite conclusions, so they are not offered.

Lecane luna Müll. (*Cathypna.*)

	Station I	Station II	Station III	Daily	Hourly
Average	10	677	251	....	....

Identification uncertain. Recorded only four times at Stations I and II in small numbers, and once at Station III. Probably adventitious. At any rate unimportant.

Notholca striata Müll.

	Station I	Station II	Station III	Daily	Hourly
Average	165	1,692	847	....	....

Identification satisfactory. Count included a small number of different forms most of which were considered varieties with perhaps one or two other species. Only six catches at Station I at rather wide intervals, in very small numbers and mostly in the first three months. Occurrence at Station II in every month except December, seven catches in first three months, one catch in each month thereafter up to December. Numbers always small. Maximum, 16,000, April 5. Recorded nine times at Station III, seven times from January 23 to April 19 and twice in November. Numbers always small but considerably larger in November than at other times. It is clear from these records that this form is intolerant of sewage and of summer conditions, probably including temperatures, though the monthly occurrence at Station II may indicate the influence of a food factor. At any rate the optimum temperature seems to be below 15° C. The seasonal distribution at our Station III most nearly resembles that noted for Illinois.

Polyarthra trigla Ehrbg. *(P. platyptera.)*

	Station I	Station II	Station III	Daily	Hourly
Average	410,770	35,241	58,037	662,712	1,267,469

Identification certain. Recorded in every month at all stations. Occurrence at Station I very constant after January 12, only two absences, both in November. Maximum on May 7, culminating a gradual increase from first appearance, numbers well sustained after that except for a drop in June, another in November and the final decline in December. Continuous record at Station II except for two misses in June, one in August, one in October and three in November. Maximum on September 6 in a well defined pulse. Record at Station III began on January 19, after which there was one miss in March, one in June, one in October and three in November. Maximum on September 20 in a minor pulse. The character of the record at Station I suggests the idea that temperatures may vary widely without appreciable influence except as they approach the lower recorded limits. Even here the influence may be through the food supply instead of direct. Stagnation appears to be slightly favorable. This is next to the most important species numerically, of rotifers at Station I.

Recurrent pulses are prominent at all stations as follows:

Station I		Station II	Station III
Jan. 15	July 30	Feb. 8	Feb. 8
Jan. 29	Aug. 9	March 8	Apr. 26
Feb. 8	Aug. 20	March 29	May 31
Feb. 23	Sept. 13	May 10	July 12
Mar. 8	Oct. 18	May 24	Aug. 2
Apr. 13	Nov. 1	June 28	Aug. 31
Apr. 26	Nov. 19	Sept. 6	Sept. 20
May 7	Nov. 30	Oct. 18	Oct. 18
June 3	Dec. 14	Dec. 14	Dec. 6
June 25	Dec. 31		
July 12			

These pulses at Station I are even more distinctly marked than in Illinois, which of course might be expected from the very large numbers distributed over the entire year. The correspondence of these pulses with those of chlorophyll bearers is quite close, thirteen being within seven days of the same date.

Polyarthra trigla eggs, attached.

	Station I	Station II	Station III	Daily	Hourly
Female, average	35,511	431	408	723	40,686
Male average	342	4,100			8,138

Identification certain. Probably most eggs became detached in manipulations and the records are to that extent unreliable. Certainly there are some very curious features to the records as they stand. Female eggs only were recorded at Station III in the regular series and then in small numbers at wide intervals, but the hourly series from the same canal, but a mile away, showed great numbers of both sexes. At Station II the numbers of female eggs were also scant but in the two catches of male eggs one was rather large. At Station I, female eggs appeared irregularly in small numbers from the last of February to the end of March, after which the occurrences were regular and in rather large numbers till May 11 when they abruptly failed. Only a very few catches were found in the interval to mid-November when the occurrence became regular again for several weeks. The records of male eggs came in November.

Such records are quite unsatisfactory as it is evident that they do not show the real numbers of eggs produced, in view of the large numbers of females recorded at all periods at all stations. Quite probably many of the free eggs counted as *Keratella* and *Filinia* eggs should have been referred to *Polyarthra.* This was suspected early in the count and the eggs were frequently examined for distinctive characters in the groups but none were found that could be used accurately while counting.

Rotifer eggs, winter, free, unidentified.

These were counted merely as a matter of routine in trying to give attention to everything found. There is not enough certainty in any observation concerning them to make comment desirable.

Synchaeta sp.

	Station I	Station II	Station III	Daily	Hourly
Average	76,696	35,039	83,865	19,850	25,890

Identification of genus satisfactory. Judging from living material, three or more species were represented in the counts but they could not be accurately distinguished in preserved material. *S. tremula,,* *S. stylata* and *S. pectinata* were probably most often present. Although the assemblage was recorded at Station I in every month of the year, the catches were few and small during the first three months and in July, August, September and October. The maximum occurred on June 25 in a strongly developed pulse. The occurrence at Station II was somewhat similar except that there were no large numbers till July when there was a fairly strong pulse. The maximum came, however, in the larger November pulse. At Station III the numbers were more evenly distributed from March to December, August being the only later month with very small numbers. The November pulse was largest on the whole but the maximum came on May 31 in a catch following a lapse and preceding two lapses. Such irregular records, in addition to the difficult identification make it necessary to be cautious as to conclusions. Still it seems clear that sewage is beneficial and that stagnation with high temperature is harmful.

Trichocerca capucina W. & C. *(Rattulus capucinus.)*

	Station I	Station II	Station III	Daily	Hourly
Average	246	4,777	1,004	413	9,123

Identification uncertain. Genus probably correct in all cases. Recorded only four times at Station I in small numbers and at wide intervals; seven times at Station II, once in fairly large numbers; eight times at Station III, all in small numbers. Unimportant numerically in our plankton. Probably adventitious.

Trichocerca iernis Gosse. *(Rattulus gracilis.)*

	Station I	Station II	Station III	Daily	Hourly
Average	13,097	21,577	46,414	88,913	285,187

Identification uncertain. May include other species. Not recorded at Station I till May 27 and not appearing regularly till July 3. Fairly constant through July and August and for a time in September, and October. Maximum in July. Occurrence at Station II almost limited to July, August and September with maximum in September. Conditions similar at Station III with a slightly longer period of regular occurrence. Maximum in September. Evidently favored by higher temperatures and quiet waters. Larger numbers at Station III than in river suggest that more organic matter in the water is helpful, though the organism does not do so well in the dilute sewage of Station I.

The following Ploima were only recorded once or twice, or were only recognized in living material.

Ascomorpha ecaudis Perty.
Asplanchna priodonta Gosse. Once, I.
Asplanchna sieboldii Leydig.
Asplanchnopus multiceps Schrank. Once, I and III.
Diaschiza exigua Gosse.
Diaschiza gibba Ehrbg.
Diurella porcellus Gosse. Once, II and III.
Diurella tenuior Gosse. Twice, I, and once, II and III.
Euchlanis dilatata Ehrbg. Once, III.
Filinia cornuta Weisse. Once, II.
Lecane ungulata Gosse. Once, III.
Lepadella ovalis Müll.
Macrochaetus subquadratus Perty. Once, III.
Monostyla cornuta Müll.
Monostyla lunaris Ehrbg.
Mytilina mucronata Müll.
Notholca longispina.
Notholca egg, attached. Once, III.
Notommata aurita Müll. Twice, I, once, III.
Platyias quadricornis Ehrbg.
Pleurotrocha petromyzon Ehrbg.
Rhinoglena frontalis. Once, II.
Trichocerca endoparasitized. Once, II.
Trichotria curta Voronkov. Twice, II, once, III.

Scirtopoda

Pedalia mira Hudson was found in very small numbers once or twice in fresh material from Stockton Channel but not in regular catches for 1913.

GASTROTRICHA

Chaetonotus nodicaudus Voight and another species were each recorded once at Station I. They are known to be present in the locality in larger numbers and are, no doubt, strictly adventitious.

ENTOMOSTRACA

	Station I	Station II	Station III	Daily	Hourly
Average	560,149	22,022	22,551	1,498,724	83,099

With the exception of three specimens of *Gammarus* found at Station III the Crustacea recorded consisted of Entomostraca. Of this group only the Cladocera and Copepoda were of any importance in our plankton. Entomostraca were recorded in every month of the year at all stations, but the numbers were small everywhere during the first three months and there were some misses at all stations at that period. In addition, Stations II and III showed occasional absences up to May and June, and in the last two months of the year. The greatest abundance at all stations was in July, August and September with the maximum in August or September at all.

The count of Entomostraca is unsatisfactory for two reasons: first, specific identifications were too difficult for the writer under the conditions of work; second, the method of counting permitted too much error. Special trials showed that even distribution of Entomostraca in the counting cell seldom occurs. As the records stand, the main error was due in most cases to counting only the same fractional field as was counted for smaller organisms. It was the intention to make a special count of Entomostraca later in order to correct this, but an examination of the records showed that it was not probable that the limited increase in accuracy of count would make any material change in the possible conclusions. For that reason the intention of recounting was abandoned. So far as can be estimated from several recounts made at random, the variance in the count by the two different methods is mainly from 10 to 25 per cent.

Cladocera

	Station I	Station II	Station III	Daily	Hourly
Forms recorded	3	4	4	2	2
Individuals per cu. meter	3,836	7,385	9,197	7,432	34,752

The Cladocera were rarely prominent at any station. There was probably a much larger number of forms present than was recorded, since names were given only to those with conspicuous characters. The averages were distinctly lower at all stations than they were found to be in Illinois, except for one year there of recurrent floods. Since 1913 seems to have been an unusually stable year here, there is reason for believing that the Cladocera are naturally fewer here. They were recorded in every month of the year at some station but the catches were few and far between and the numbers small at all stations until August. The maximum came on October I at Station I and in September at Station II and III, after which the numbers rapidly declined at all stations. Our records therefore agree with those of Illinois in showing the favorable effect of stable (or even stagnating) water and of high temperatures. We have the further indication that sewage is detrimental since Station I had so much fewer numbers than either of the other stations. The explanation of the deleterious effect of flood waters in Illinois (Kofoid 1908) applies equally well here. The evidence for recurrent pulses is not convincing here at any station.

DISCUSSION OF GENERA

Bosmina longirostris O. F. Müll.

	Station I	Station II	Station III	Daily	Hourly
Average	746	5,000	5,145	1,652	13,684

Identification probable. This form was rare at Station I, being recorded only eleven times in small numbers, six times in September and October, the rest scattering. Catches at the other stations were almost confined to the same period but there were more of them and the numbers were larger. Clearly favored by warm, stagnating water and retarded by sewage.

Chydorus sp.

	Station I	Station II	Station III	Daily	Hourly
Average	....	1,662	1,555	....	....

Identification doubtful. Recorded seven times at Station II mainly in August and September, and five times at Station III at irregular intervals. No definite conclusion possible, though the indication is that sewage is injurious, while warm stagnating water is favorable.

Sida sp.

	Station I	Station II	Station III	Daily	Hourly
Average	2,960	738	1,325	5,781	21,068

Identification doubtful. There was probably considerable confusion with other forms, especially *Daphnia.* Recorded frequently at Station I from early June to late October, rarely at other times. Numbers always small except on October 1 (105,792). Recorded twice at Station II and seven times at Station III, nearly all in the warm months. Seems to be a warm water form favored by sewage and quiet waters.

The following other genera of Cladocera were thought to be present:

Alona sp.
Bosmina sp. All three stations.
Daphnia sp.

Ostracoda

Ostracoda were mainly notable for their absence. *Cypris* sp. was the only form recognized and it was rare. It was not recorded from the preserved material. Inasmuch as it has been found in abundance in ditches and temporary ponds about Stockton, it must be regarded as strictly adventitious.

Copepoda

	Station I	Station II	Station III	Daily	Hourly
Forms recorded	4	3	3	4	3
Individuals per cu. meter	556,312	14,882	14,549	1,488,421	189,469

Copepoda were recorded in every month of the year at Station I, and they were entirely missing only at Stations II and III in December and November, respectively. Numbers were small at all stations through the first three months and in the last month. At Stations II and III they only reached 100,000 in three catches in September at the former, and one catch at the latter. There was no increase in numbers at either place until May and the decline was very rapid after September. On the contrary, Station I showed very marked and steady increase in numbers after March and the decline after September was gradual, though starting abruptly with the close of the month. The maximum at Station I came in August according to the record but it was so nearly eqalled in September that a recount might show it really to be in that month. However, this does not affect the general conclusion that the warmest months are most favorable, the culmination coming with approaching stagnation. The record also clearly shows that the dilute sewage of Station I was distinctly favorable to this group.

Specific identifications were not attempted and there was certainly some confusion of forms during the count. Some of these errors could be corrected by a recount, but in the writer's judgment there would not be enough advantage to warrant the great effort involved.

Dr. C. D. Marsh, of the United States Bureau of Plant Industry, very kindly identified a few forms from a very limited amount of material sent to him. He noted the presence of *Cyclops americanus* Marsh, *Cyclops prasinus* Fischer, and *Cyclops albidus* Jurine. No other Copepoda were found in the samples sent to him but the writer is certain that some other forms occurred at times in limited numbers. Since Cyclops completely dominated the other genera in numbers, discussion of seasonal distribution will be deferred till discussion of that group is reached.

DISCUSSION OF GENERA

Canthocamptus sp.

Identification fairly certain. Recorded only twice at Station I, thrice at Station II and five times at Station III in small numbers and at wide intervals, but mainly in spring and fall. This genus has been found in abundance in some of the shallow temporary ponds in Stockton in February, March and April, hence it is to be regarded as adventitious in the plankton collections.

Cyclops sp.

	Station I	Station II	Station III	Daily	Hourly
Average	165,660	2,238	7,929	525,978	83,099

Identification of genus usually certain. May include some other genera when preservation of the individual was poor. As mentioned above, Dr. Marsh has indicated the presence of three species in the first half year. These were *C. americanus* Marsh, *C. prasinus* Fischer, and *C. albidus* Jurine. It is probable that there were few other species and that these furnished the principal numbers.

The genus was rarely missing at Station I, though the numbers were comparatively small before May and in December. Only two catches were recorded before June 21 at Station II and two after September 13. Conditions were somewhat the same at Station III, though the number of catches before mid-June was larger. The evidence seems to be conclusive that the genus is favored by sewage, by stagnation and by high temperature. It does not seem possible that recounting by any method could change the basis for such conclusions.

There is some evidence of recurrent pulses at Station I but a recount would be necessary before listing them with full confidence. As it stands, no very close relationship to the algal pulses can be shown except in two or three cases.

Diaptomus sp.

While this genus does not appear in the record, it is so certain that it was present that definite mention of the fact seems desirable. It may have been sometimes included in the count with Cyclops, but the numbers were never very large and it may have failed to get into the counting field except in one or two cases.

Nauplius spp.

	Station I	Station II	Station III	Daily	Hourly
Average	392,240	11,722	5,239	962,366	106,370

All kinds of larval copepods were included under this heading. Undoubtedly, nearly all belonged to *Cyclops*. They showed practically the same characteristics of distribution at all stations as those already noted for *Cyclops*, almost the only difference being that more catches were recorded. This might be expected since such a variety of larval forms was included in the count.

No copepods other than the forms already noted were recorded from the 1913 collections. Since most of the Entomostraca were quite well preserved, it may be possible to make a critical study of the group at a later period.

MALACOSTRACA

Three specimens, probably *Gammarus* sp., were found at Station III in January, 1913. They were taken from very shallow water before the best place for collecting was found and they were evidently adventitious in the plankton.

MISCELLANEOUS

Glochidia spp.

	Station I	Station II	Station III	Daily	Hourly
Average	256	6,415	471	723	....

General identification certain. May include larvae of several species of fresh water clams. Recorded three times at Station I in July and August and five times at Station III, mostly in the same period. At Station II the numbers were much larger and the catches more numerous. Recorded three times in January and February in very small numbers and almost continuously in June and July. Sewage evidently detrimental and flood water favorable to occurrence in the plankton. Effect of temperature uncertain.

Macrobiotus sp.

	Station I	Station II	Station III	Daily	Hourly
Average	80	854	2,263	....	....

Identification satisfactory. All the Tardigrada found were referred to this genus. It was only recorded twice at Station I, eleven times at Station II and three times at Station III, always in small numbers. Evidently adventitious.

Nematoda sp.

	Station I	Station II	Station III	Daily	Hourly
Average	212	185	424	....	....

Identification of the order certain. Nothing definite known as to generic classification. Very many specimens were immature. Recorded six times at Station I in small numbers and at wide intervals, twice at Station II, and five times at Station III, these five being taken in the first three months. These are evidently adventitious forms in the plankton.

Other groups represented by only one or two forms or seen only in fresh material are as follows:

Chironomus larva. Twice, II.	Planarian.
Oligochaetes. Three times, II.	Statoblast of Pectinatella. (?)
Nais (?) sp.	Statoblast of Plumatella. (?)
Oelosoma sp.	Hydrachnida sp. Twice, II.

Summarizing, it may be worth while to call particular attention to the number of forms present at different stations in different months, and to the proportional differences in numbers of organisms at the three stations by months, as shown by the accompanying text table.

TEXT TABLE 6.—NUMBERS OF KINDS OF PLANKTONTS BY STATIONS AND BY MONTHS IN 1913

	January			February			March			April		
Stations	I	II	III	I	II	III	I	II	III	I	II	III
Bacteriaceae	1	0	0	1	0	1	1	0	0	0	0	0
Schizophyceae	7	4	3	7	4	3	6	6	6	7	7	8
Chlorophyceae	7	6	3	9	6	6	8	8	8	13	9	8
Bacillariaceae	24	28	18	22	28	28	26	34	38	27	37	33
Conjugatae	6	3	3	4	4	5	1	6	4	2	6	6
Mastigophora	6	5	5	10	6	11	8	7	7	7	6	9
Rhizopoda	2	1	2	3	2	3	3	2	4	5	5	4
Heliozoa	0	0	0	0	0	0	1	3	1	1	0	1
Ciliata	13	2	3	17	5	9	18	7	10	16	8	8
Suctoria	0	0	0	0	0	0	0	0	0	0	1	0
Rhizota	0	1	0	0	0	0	0	0	0	0	0	0
Bdelloida	3	3	2	3	2	2	3	3	2	2	2	1
Ploima	11	10	9	10	12	10	15	11	12	14	12	10
Cladocera	1	1	1	0	0	0	0	0	1	0	2	1
Copepoda	1	1	1	1	1	2	2	1	1	3	2	1
Miscellaneous	1	4	1	2	3	2	0	3	2	1	1	1
Total	83	69	51	89	73	82	92	91	96	98	90	91

	May			June			July			August		
Stations	I	II	III	I	II	III	I	II	III	I	II	III
Bacteriaceae	1	1	0	1	1	1	1	0	1	1	1	1
Schizophyceae	9	5	6	10	7	10	8	10	11	12	14	14
Chlorophyceae	10	8	8	11	8	7	11	9	10	10	10	9
Bacillariaceae	25	37	31	23	42	34	18	35	29	22	35	33
Conjugatae	1	4	2	4	4	5	5	5	5	5	6	6
Mastigophora	10	7	9	9	9	11	10	12	14	15	13	10
Rhizopoda	6	2	2	4	3	3	5	3	4	6	5	7
Heliozoa	1	0	2	1	1	2	3	4	3	4	4	3
Ciliata	8	4	5	3	3	3	7	2	2	8	5	5
Suctoria	0	0	0	0	0	0	0	1	1	0	2	2
Rhizota	0	0	0	0	0	0	0	0	0	1	2	1
Bdelloida	2	2	2	2	2	1	3	3	1	3	3	2
Ploima	16	9	15	16	15	13	16	20	16	15	16	16
Cladocera	1	1	1	1	0	1	2	1	2	2	3	3
Copepoda	2	1	1	1	1	1	1	1	1	2	2	2
Miscellaneous	1	5	0	1	2	0	1	1	1	1	1	2
Total	93	86	84	87	98	92	91	107	101	107	122	116

TEXT TABLE 6.—NUMBERS OF KINDS OF PLANKTONTS BY STATIONS AND BY MONTHS IN 1913—*Continued*

	September			October			November			December		
Stations	I	II	III	I	II	III	I	II	III	I	II	III
Bacteriaceae	1	0	1	1	1	0	1	1	1	1	0	1
Schizophyceae	12	12	11	11	10	6	9	12	11	12	5	3
Chlorophyceae	11	10	11	11	11	11	10	11	10	11	6	7
Bacillariaceae	25	28	25	28	25	31	26	29	35	32	29	36
Conjugatae	5	6	5	5	5	4	3	4	3	4	5	4
Mastigophora	15	12	16	13	9	10	14	10	12	13	8	9
Rhizopoda	6	7	6	6	4	5	7	5	6	5	4	3
Heliozoa	3	3	4	5	3	5	3	2	2	1	0	1
Ciliata	5	3	6	12	6	5	15	8	11	20	6	10
Suctoria	1	1	1	1	2	1	2	2	0	3	3	1
Rhizota	1	1	1	1	1	2	0	1	1	0	0	0
Bdelloida	3	3	2	3	3	2	3	3	2	3	3	2
Ploima	13	17	16	16	15	16	11	11	11	8	12	4
Cladocera	2	3	1	2	2	1	2	1	2	1	2	1
Copepoda	1	1	2	1	2	1	1	1	0	1	0	1
Miscellaneous	0	1	0	0	1	1	1	0	0	0	2	1
Total	104	108	108	116	100	101	108	101	107	115	85	83

This table shows some points quite well. The number of forms was lowest at all stations in January. There was then steady increase to May, when flood waters were highest and the number of forms recorded slightly less. Increase in number of forms began again in June, becoming greatest at Stations II and III in August and at Station I in October. The numbers were well sustained at the two stations until December, when there was a marked decrease. Station I not only showed increase to October, but almost equaled it in December. While it is probable that more accurate species determination might change the detail of this showing, it is not probable that the general differences would be affected.

One legitimate inference from this table is that Station I is less subject to seasonal fluctuations than either of the other stations. At present the only reasonable explanation of this fact seems to be that the dilute sewage of Station I is the prime factor, for the superficial resemblances would lead one to expect that Stations I and III would most closely approach each other in character and distribution of populations, rather than Stations II and III. But the reverse is true, and sewage is the only known factor of sufficient moment to account for it. It is true that temperatures run slightly higher at Station I, but is it not possible that this higher temperature is partly due to the rapid turnover of the great quantities of organic matter.

Aside from the question of temperature there is ample reason for assigning main influence to sewage because of the great food supply, a supply superabundant and hence essentially constant through the year, with the exception of May and June, the time of the mountain floods. The decrease in number of forms at this time strengthens the view that flood waters dilute the sewage and reduce the food supply, thus reducing reproductive and growth activities. There is also considerable loss through washing out, even with the rather low waters of 1913. The 1914 collections should certainly throw some additional light on this question.

THE DAILY SERIES

As noted elsewhere, the daily series was undertaken in the hope that it would give definite information concerning the problems of recurrent pulses and the incident conditions. This hope was partly realized, although the thirty-one days constituting the series was not enough, and it is evident that more faithful adherence to a uniform hour of collection is desirable. Since this last would involve very marked differences in condition of tide, it is probable that Stockton is not a good locality for such a test. It would be much better to try it in a locality free from tidal influence. It is also probable that the large amount of traffic past the point at which this series was taken might affect the results. At any rate, these two factors, at least, might be eliminated in some other locality. However unimportant they might later be proven to be, they do make the problem needlessly complex.

Under the circumstances it does not seem desirable to discuss individually even the more conspicuous species. Generalizations to be reached by such discussion in this series do not differ materially from those to be obtained from consideration of the larger groups. Species records are given in table 4.

Although the thirty-one days did not give a series of sufficient length to be wholly satisfactory, there are some points of decided interest. These are graphically indicated in plates 1, 6, and 3. In plate 1, showing volumes, there was a prominent pulse apex on July 13, another maximum for the series on July 18, and another almost as large on July 27. Explanation of this is afforded in part by plate 6, where it is shown that chlorophyll bearers and Protozoa and Rotifera all had pulse culminations near July 13 and July 27, while the Entomostraca showed a pulse culmination maximum for the series on July 22. It is evident that the median position of the volumetric maximum is due to its dependence on the entomostracan numerical maximum since the bodies of individual Entomostraca are so much larger than those of the other planktonts. Just why the numerical maximum of Entomostraca should fall between pulses of other groups does not so clearly appear. The most obvious explanation is that the abundant food supply furnished by other organisms near July 12 led to abundant reproduction of Entomostraca (mainly *Cyclops*), which in turn reduced the number of other organisms and led to its own decline. The pulse culmination of other organisms at July 27 would then be due to rapid recovery from the inroads of the Entomostraca.

On account of insufficiency of records, consideration of light relations does not give very satisfying aid toward an explanation of these pulses. Both our records and those of Mr. Higby, the Stockton weather observer, were made at a particular time of day and so fail to show the day as a whole so far as clouds, etc., were concerned. It is also true that such records fail to show the influence of the wind except for a small part of the day. As the records stand (table 7), the daylight conditions appear to have been too nearly uniform through the series to have had any marked influence on plankton pulses.

Reference to the lunar cycle for July, 1913, however, suggests the probability of its having a strong influence in this connection. It may be noted that the beginning of the marked rise in production of chlorophyll bearers came on July 10 at the first quarter of the moon, and that the apex of the pulse for these organisms came on July 17, at full moon. The rapid decline thereafter may be easily explained by the unusual abundance of Entomostraca and other predatory animals, while the smaller pulse culminating on July 27 might be due to partial recovery from their attacks. The evidence here that the waxing moon brings rapid increase of chlorophyll bearing organisms is as strong as could possibly be imagined, since the record covers only a single lunar cycle. It makes one wish that the daily records might have been carried over several lunar cycles in order to find the variations which might be expected. This particular series certainly confirms in a definite way Professor Kofoid's argument (1908) that pulses of chlorophyll bearers, and consequently of other planktonts, tend to accompany increases of lunar light.

The important features in the records of this series are concerned most directly with the chlorophyll bearing organisms, as just discussed. But, as a matter of interest, brief mention will now be given of the typical Protozoa (Mastigophora are included above with chlorophyll bearers) and of the Rotifera. Examination of plate 6 discloses the fact that Protozoa showed pulses at about the same periods as did the chlorophyll bearers, slightly preceding the latter at the first and coinciding at the second. The evidence which this gives of close association of the two groups is the only important feature. The analysis of the relationship presents some decided difficulties. In the first place, most of the Protozoa found here at this time were of the type which depends upon bacteria for food rather than upon green organisms (at least no Protozoa were ever observed with green organisms in their bodies). The presence of green organisms might favor them, however, by excretion of oxygen and absorption of carbon dioxide. Aside from these considerations, the only reason for coincidence of pulses in the two groups would seem to be in general conditions favorable to both.

In the case of the Rotifera, the abundance of food with which most of them are furnished by an increase in green organisms would seem sufficient to account for close correspondence of pulses of the two groups. Unfortunately for the validity of this view, the first rotiferan pulse (pl. 6) culminates on July 12, five days before the culmination of the pulse of chlorophyll bearers. It is also true that the second pulse coincides exactly with that of the green organisms. If the food relationship were the deciding factor, the rotiferan pulse should always follow. It is possible that here again is a case in which the gaseous content of the water forms one of the connecting links for two groups of organisms.

SUMMARY

Considering the large numbers of factors which might influence the location of pulses of various organisms or groups of organisms, it is necessary for the present to say that the showing made by this daily series of a single lunar cycle may be to some degree accidental. Hence no inference can be regarded as proven. The important inferences suggested by these daily records may be summarized as follows:

1. There was a very distinct increase in numbers of green organisms as the light of the moon increased.
2. There was an abrupt decrease in green organisms as Entomostraca increased, which was followed by a partial recovery after the entomostracan maximum.

3. The two pulses of chlorophyll bearers were closely accompanied by similar pulses of Protozoa (exclusive of Mastigophora) and of Rotifera.

4. It is very necessary to have similar series covering several lunar cycles in order to evaluate the various factors of distribution and the bonds of relationship of plankton organisms.

Before leaving the discussion of this series, the point should be emphasized that daily collections frequently give a very different view of the situation from any that may be obtained at longer intervals. Comparison of plates 3 and 1 (graph Station I and Daily) shows this very clearly. Referring first to plate 1, it will be seen that although the regular Station I series was taken twice a week the difference is very great. In the Station I regular series the volumetric maximum came on July 30, but the daily record shows that four catches (July 13, 18, 20, and 27) exceeded it, two of them greatly. The semiweekly record shows this maximum on the rise of a pulse while the daily record shows it as on the decline of another. The daily record also shows marked fluctuations in volume of the catches during this lunar cycle which are not indicated by the other.

If the regular series had been taken only once a week (which is usually the shortest interval used by investigators), the dates would have been July 5, 12, 19, 26, and August 2. Comparing this with the daily record we see that it would have shown an erroneous picture of conditions since it would have indicated a considerable abrupt rise in volumes to fairly stable, higher levels.

Turning to plates 3 and 6, we find the same things true. In the case of the Entomostraca the remarkable pulse from July 20 to 23 is entirely missed by even the semiweekly method. While the pulses of the other groups are not entirely missed, they appear much more abrupt in the regular series than they really are.

In consequence of these remarkable differences it is surely clear that only the most general conclusions may be safely drawn from series of catches taken at intervals greater than one day.

THE HOURLY SERIES

This series, covering a period of about twelve hours on August 11, was undertaken in the hope of finding some indication of the importance of the daily tidal currents in a study of the plankton. It was also expected that some information might be obtained as to diurnal influences of light. The series is too short to be satisfactory (twenty-four hours would be better) and several days should be covered instead of one.

Despite these defects, the records indicate some points of interest. It happened that on the day selected low tide came at about 11 A.M. at Stockton, but there was no available way of recording the tide accurately. There is nothing in the record that can be positively connected with tides.

Still less than in the Daily series does there seem to be anything indicated by the species record which is not as well shown by major groups. For that reason the general discussion only will be given. Reference to table 5 will easily show such detail as has been recorded.

Since chlorophyll bearing organisms give, to a large extent, the basis of interpretation of plankton conditions they may receive first attention. Plate 6 (hourly) shows a preliminary drop in numbers from 7 A.M. to 8 A.M. a nearly uniform succession of catches to 12 M. and a constant rise through the remainder of the series to the close at 6:45 P.M. A graph of such very prominent characters demands explanation, but the demand cannot be fully satisfied from the present records. During the forenoon period of nearly uniform numbers the tide was ebbing, the air was hazy with full sunlight, there was little wind and the water was nearly smooth most of the time. In the afternoon period of rapidly and constantly rising numbers there was flowing tide, hazy air with full sunlight, strong wind, almost a gale at the close, and very rough water, with strong cross currents due to wind. The water temperature varied from 24° C at 7 A.M. to 26° C from 11 A.M. to 4 P.M. and to 25° C at 6:45 P.M. Among the observable factors involved, the temperature seemed to be the only one of sufficient constancy to account for the increase. Light was the only other factor that seemed likely to have had a beneficial effect and it was surely very much poorer in the afternoon on account of rough water. In view of such adverse conditions as rough water and poorer light it would have been reasonable to expect that there would at least be no increase in numbers of plankton in the afternoon. As the evidence stands it points distinctly to the conclusion that temperature was the dominant factor in the diurnal fluctuation of chlorophyll bearers.

If there had been only one or two larger catches in the afternoon or if there had been fluctuation in numbers there might be some question as to the sufficiency of the above evidence, but it will be noted that after 12 M. there was a steady increase broken by only one fall below the last preceding number and this break occurred at 6 P.M. A more detailed analysis of the chlorophyll bearing group very forcibly emphasizes the reliability of the record covering this point. In plate 11 it will be seen that Schizophyceae and Bacillariaceae have very pronounced increase after 12 o'clock, while Chlorophyceae and Conjugatae have moderate increase, somewhat wavering, and that Mastigophora have a strong but erratic rise·from greater numbers at 1 P.M. a low minimum, to 7 P.M., almost equal to the forenoon maximum. It is also clear that all these except the Chlorophyceae show the sharp temporary decline at 6 P.M. Looking up species records in table 5, we find that the 6 P.M. decline is mainly due to deficiencies in numbers of *Nostoc* and *Cyclotella*. Also that the erratic record of Mastigophora through the day is due principally to *Chromulina, Hemidinium* and *Trachelomonas,* all very difficult to identify or to count. Taken as a whole, the evidence indicates that the records give a fairly dependable idea of the history of the chlorophyll bearers through the twelve-hour period. From this history the tentative conclusion may be drawn that temperature is a major if not the determining factor in daily fluctuations of numbers. It may be, however, that wind and waves do not exclude enough sunlight in shallow water to make any great difference and that the greatest influence in this case was due to sunlight. This last view is supported by the history of the other groups.

In case of the Protozoa, the Rhizopoda (pl. 11, and table 5) and the Heliozoa (table 5) give responses similar to chlorophyll bearers, i.e., an afternoon rise; but their numbers are relatively small, for most of the catches and their afternoon prominence might easily be due to the stirring of bottom waters by the strong currents caused by combined wind and tide. This leaves, then, the Ciliata as the only typical protozoan group with a reasonably clear record. Reference to table 5 shows the ciliate assemblage to consist almost entirely of *Holophrya, Tintinnidium* and two *Vorticella* and that they all agree in a strong forenoon representation with an afternoon decline, well pronounced for three of them. Since temperature would be expected to affect these as markedly as it did the chlorophyll bearers, while light probably would not, we have a valid conclusion indicated that light is the major factor in the afternoon rise in numbers of chlorophyll bearers.

The Rotifera (pl. 19) show substantial agreement with the Ciliata, both collectively and individually. Hence we are still further led to doubt the dominance of temperature.

As to Entomostraca (pl. 19) the catches of Cladocera were too variable to give any information, and those of Copepoda were also rather indefinite. There was not much difference between the forenoon and afternoon catches either of Cladocera or of Copepoda or of both together.

As shown by plate 1, the whole plankton volume increased strongly through most of the twelve hours, both actually and also relatively to the volume of sediment. No explanation of this fact seems to be available, although the distribution of the chlorophyll bearers may be of sufficient importance.

The foregoing discussion leaves a final impression which is badly muddled. This may truly represent the facts, but it is not satisfying to the mind. A different form of discussion may help to clear the problems involved. Examination of tables and plates already mentioned discloses the fact that, based on distribution through the twelve hours, there were two fairly well marked groups of planktonts, consisting on the one hand of the chlorophyll bearers and on the other hand of the more highly motile animal forms. The former showed a steady increase in numbers as the hours of afternoon passed. The latter showed just as pronounced a decrease, though less uniform, from the forenoon numbers.

Apparently the general factors which could probably be involved are the following: vital, chemical and physical. While specific subdivisions of these make a formidable list, which is further complicated by their very general interdependence, it seems that some are sufficiently dominant to enable tentative discussion, as in the accompanying list:

Vital Factors
- Locomotion
- Irritability
- Feeding
- Respiration
- Excretion
- Reproduction
- Other organisms

Chemical Factors
- Organic content
- Mineral content
- Gaseous content

Physical Factors
- Viscosity
- Turbidity
- Suspended solids
- Currents
  - Tide
  - Wind
- Oscillations
- Temperature
- Light
- Pressure

Locomotion, among the vital factors, is characteristic of the typical animal forms, but its effectiveness may be increased or diminished by respiration and excretion, or other factors, in the same animal or in neighboring organisms of any type. It may be similarly affected by the gaseous content of the water, which in turn is determined to some extent by temperature, light and currents in water and air, and so on with an indefinite number of combinations. It is necessary to limit our present discussion to those combinations which are most probably determinative within the twelve-hour period. Continuing the reference to locomotion with this limitation in view, we have to note that the more typically animal organisms may have been less numerous in afternoon catches because of migration to bottom layers of water, the lowest of which the net did not reach. Such a migration might be due to the influence of several other factors. Rising temperature might induce it directly by discomfort or indirectly by lessened viscosity of water, relatively increasing the influence of gravity, or by reducing the gaseous content, probably not greatly effective, or by changing the gaseous content through more oxygen excretion and carbon dioxide absorption by green organisms, or by increase of disagreeable excretions from the surface organisms as they became more active under higher temperature.

Locomotion might also be affected by the wind, directly by discomfort due to surface agitation, indirectly by interference with food taking near the surface through rapid oscillations of surface layers of water. Leeward drive of the wind is not considered because it would affect green organisms as much or more than the locomotor organisms.

Light might affect locomotion directly by discomfort and indirectly by the increase of starch manufacture, in green plants, with the larger amount of oxygen liberation and carbon dioxide consumption, thus shifting the region of the mean gas content to which motile forms are accustomed, to some distance below the surface.

Locomotion might affect non-motile surface organisms through removal of predatory organisms by migration, thus letting growth and multiplication go on unchecked. It would not be necessary for an organism to pass a whole life cycle in order to show this effect. Undoubtedly there are at any given moment in a plankton population many very young individuals, many just maturing, and many just ready to divide. Unfavorable conditions would arrest or deter developmental processes which would be again accelerated by favorable conditions. At a favorable time, then, many new organisms, which had been restrained during an adverse period, might be liberated and allowed to grow.

Reproduction as a factor influencing diurnal oscillations of numbers may not be important, but, for the reason just stated, it probably is. If, in addition to this, it could be shown that any considerable number of plankton forms accelerate both growth and fission processes with diurnal rise in temperature and that fission may occur two or more times in twenty-four hours, the argument in favor of dominance of temperature through the reproductive factor would be convincing. The writer has examined large numbers of publications without finding definite discussion of this point. Apparently the only cases in which the number of generations in a twenty-four hour period has been accurately determined have shown what occurred under special laboratory conditions only, and they do not tell what occurs with a mixed population under natural conditions. Even so, the published records of such studies deal almost entirely with animal types. Since the increase of numbers due simply to acceleration of vital processes is sufficient to account for any probable influence of the reproductive factor in this series, it is doubtless best to say that the addition of a distinct generation during the twelve-hour period is improbable.

It is also true that reproduction may be influenced by light. Some organisms may be stimulated to greater reproductive capacity, some to less. In the green organisms, with which we are now mainly concerned, it may be seen that light, through acceleration of food manufacture, might cause increase of fission, due to increased availability of energy producing and building materials. On the other hand, it seems to be pretty well known that in higher algae and phanerogams food manufacture is characteristic of day time, growth and reproduction of night, i.e., the plant does not carry on all its functions equally well at the same time.

The gaseous content of the water would be mainly effective, under ordinary conditions, through its influence on the irritability of the organisms and through its more or less direct connection with their feeding and respiration. A very slight difference in dissolved gases would surely change the responses of some organisms to light and other stimuli, but it is hard to determine the definite connection of that fact with the conditions now under consideration. As Birge and Juday have clearly shown, the physiology of plankton organisms cannot be fully determined by tests under artificial conditions such as those of the laboratory, e.g., the capacity of various animal forms for meeting anaerobic conditions of the environment is vastly greater in natural bodies of water than it is in artificial cultures. In the present instance it seems possible that the decline in numbers of certain zooplanktonts toward midday might be due to negative phototropism caused by supersaturation of water by oxygen liberated during photosynthesis by plants. But it might be due to negative phototropism due to rising temperature, or to negative phototropism or positive geotropism due to increasing agitation of the water, or to various other factors or combinations of factors.

So far as green organisms are concerned, it may be readily understood that photosynthetic and growth and reproductive processes might all be accelerated by the presence of carbon dioxide with a rising temperature and a considerable amount of sunlight (though less than the maximum because of rough water). It is also true that increase of oxygen formation might increase the buoyancy of the plant cells so that larger numbers of them would be in the region of water traversed by the net. This is especially probable in the presence of wind because any agitation of the shallow (two and one-half meters) water would be an aid to buoyancy.

There is no possibility of segregating tidal from other influences on our present information. So far as the currents, wind and tide, and oscillations of the water are concerned, taken all together, they might induce negative phototropism, or positive geotropism and thigmotropism in the animals. They might also affect the green organisms by aiding buoyancy and by increasing the circulation of the water, thus bringing more carbon dioxide to the absorbing surfaces and rapidly removing oxygen and other waste products from such surfaces.

Perhaps enough has already been said about temperature, but it will do no harm to recall that it affects flotation of organisms through changes in viscosity, that it probably plays an important part in reversal of tropisms under natural conditions, and that any change either accelerates or retards all of the activities of the organisms.

For this series the influence of light cannot be segregated from that of temperature since both are dependent on the sun's rays. It may be said, however, that light plays more or less part in reversal, or intensity of reversal, of tropisms of organisms, and that it is of major importance in photosynthesis and thus in effect on the gas content of the water.

So far as the other factors listed above are concerned, it is not seen that they could be of appreciable influence in this period under the conditions of variability recorded for the organisms and for the general factors involved.

One point of general interest may be noted in plate 1, where it appears from the volumetric graph that the total volume decreased gradually to midday and increased again through the afternoon, but that the net volume of plankton increased fairly steadily throughout the twelve hours. This is not what might be expected because the wind and tide of the afternoon should, theoretically, stir the water enough to increase the relative amount of silt. The unexpected silt diminution might be due to collecting conditions, the stronger combined current from wind and tide in the afternoon carrying away the silt stirred up by impact of the drain cup cylinder upon the bottom.

CONCLUSION

In conclusion it may be said that the following points appear distinctly from the present study:

1. San Joaquin waters are capable of supporting abundant plankton, and they do so in the vicinity of Stockton.
2. The plankton of the sewage-laden Stockton Channel is distinctly different from that of the river, the number and volume of its animal forms being especially conspicuous as distinguished from the algal dominants of the latter.
3. Temperature is, within certain limits, the determining factor in seasonal distribution. This may be by direct retardation of growth and reproduction in organisms, or by indirect influence through food supply and gaseous content of water.
4. Water currents above a very moderate speed are distinctly inimical to plankton development.
5. The peculiar succession of rainy season and dry season has resulted in an autumnal maximum of plankton about Stockton, a condition directly contrary to that of vernal maxima recorded by various observers in other localities.
6. Collections taken at intervals of one week or more do not furnish a basis for accurate determination of plankton distribution through the year. Daily collections properly taken would probably do so.
7. There is some evidence in favor of the idea that increase of lunar light tends to the increase of plankton, especially chlorophyll bearers.
8. There is evidence to show that fluctuations in amount of plankton occur at various hours of the day.

9. The abundant occurrence of *Bacillaria paradoxa,* generally listed as a typical brackish water form, is notable. This seems to be one case in which marked departure from a typical chemical environment has not visibly affected structure or behavior.

10. Lastly, it is necessary to emphasize the fact again that whatever fault or error there may be in this report is chargeable absolutely to the writer. In some cases expert advice has not been followed after being asked. On the other hand, there is the deepest obligation to the persons already mentioned for advice and assistance.

ADDENDUM

Since writing the discussion of the series of plankton collections of 1913 the statistics for the collections of 1914 and 1915 have been compiled and examined. Inasmuch as weekly collections only were taken in 1914 and 1915, and since two stations only were used in each of these years, the records are much less comprehensive than those for 1913. On this account, and also because the 1914 and 1915 records are essentially similar to those for 1913, it seems inadvisable to prepare them for publication. The collections for 1914 and 1915 have already been deposited with the Department of Zoology of the University of California and it is the writer's intention to deposit the manuscript records in the same place.

Transmitted August 15, 1918.

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913

1913	Spirillum undula	Anabaena sp	Aphanocapsa sp	Gloeocapsa conglomerata	Glococapsa sp	Gomphosphaera aponinae
1/5						
1/8	400					
1/12						
1/15	400					
1/19	26,448					
1/22		800				
1/26					400	
1/29						
2/2					400	
2/5					2,400	
2/8					800	
2/12						
2/15	800					
2/19		800				
2/23						39,672
2/26						1,600
3/ 1	1,600					3,200
3/ 5						52,896
3/ 8						
3/12						
3/15					52,896	
3/19						
3/23						
3/26						
3/29					1,600	
4/ 2		1,600				
4/ 5					52,896	
4/ 9						6,400
4/13						3,200
4/16		1,600				
4/19		1,600				
4/23					52,896	
4/26					79,344	3,200
4/30						
5/ 3		79,344				3,200
5/ 7	1,600	9,600				1,600
5/11	1,600	52,896				1,600
5/14		105,792			105,792	3,200
5/17		6,400				
5/21		158,688				105,792
5/24		3,200			105,792	3,200
5/27	3,200				211,584	
5/31	105,792				3,200	3,200
6/ 3	3,200	6,400	1,269,504		105,792	
6/ 7		25,600	740,544		105,792	
6/11	3,200	6,400	846,336			
6/16	3,200	6,400	317,376		6,400	3,200
6/18	105,792	6,400	740,544		3,200	
6/21		370,272	687,648			
6/25	3,200	32,000	1,110,816			317,376
6/28	3,200	370,272	687,648			
7/ 3	3,200		687,648		1,600	
7/ 5	105,792		476,064		264,480	
7/ 9		158,688	687,648	38,400	370,272	
7/12		1,163,712	1,005,024	899,232	581,856	
7/16		846,336	1,216,608	158,688	1,375,296	
7/19		581,856	158,688	3,200	528,960	
7/23		105,792	6,400		264,480	
7/26		211,584	264,480		1,005,024	
7/30		158,688	211,584	3,200	317,376	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Spirillum undula	Anabaena sp	Aphanocapsa sp	Gloeocapsa conglomerata	Glococapsa sp	Gomphosphaera aponinae
8/ 2	3,200		3,200		105,792	
8/ 6					264,480	
8/ 9		3,200	12,800		528,960	
8/13		105,792	3,200		317,376	
8/15	3,200	158,688	12,800	3,200	370,272	
8/20	3,200	6,400	211,584		423,168	
8/23		211,584	105,792		476,064	
8/27	105,792			105,792	899,232	
8/31		19,200		105,792	370,272	
9/ 2		3,200		105,792	370,272	158,688
9/ 6	3,200	12,800	105,792		634,752	
9/ 9		264,480	105,792		370,272	
9/13		264,480	105,792		370,272	
9/17		6,400			476,064	
9/20		6,400	52,896		740,544	
9/24		211,584			423,168	52,896
9/27		6,400			687,648	
10/ 1	52,896	105,792			952,128	
10/ 4		6,400	52,896		740,544	52,896
10/ 8		52,896	105,792		528,960	
10/11	52,896				423,168	
10/15	52,896		52,896		158,688	
10/18					52,896	
10/22					52,896	
10/26	52,896				158,688	
10/29	105,792				264,480	
11/ 1	158,688				634,752	
11/ 5	105,792				423,168	
11/ 8	52,896				264,480	
11/12	238,032		105,792		634,752	
11/15	158,688				581,856	
11/19	52,896				317,376	
11/22					476,064	
11/26						
11/30			52,896		105,792	
12/ 3	1,600				52,896	
12/ 6			3,200			
12/10		18,400			19,836	
12/14	26,448	26,448			66,120	
12/17	26,448	26,448			52,896	
12/20	26,448				13,224	
12/24	400	800			39,672	
12/27	400	800			46,284	
12/31	19,836				39,672	

1913	Inactis tinctoria Agardh	Merismopedium glaucum	Microcystis sp	Nostoc sp	Oscillatoria formosa	Oscillatoria sp
1/ 5					800	
1/ 8					800	
1/12						
1/15						
1/19						
1/22			800			
1/26						
1/29				800	400	
2/ 2				800		
2/ 5						
2/ 8						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Inactis tinctoria Agardh	Merismopedium glaucum	Microcystis sp	Nostoc sp	Oscillatoria formosa	Oscillatoria sp
2/12						
2/15						
2/19						800
2/23						
2/26					3,200	
3/ 1						
3/ 5						
3/ 8						
3/12						
3/15				1,600		
3/19					79,344	
3/23						
3/26					52,896	
3/29					3,200	
4/ 2					3,200	
4/ 5					1,600	
4/ 9			3,200		6,400	
4/13						
4/16			1,600		1,600	
4/19					3,200	
4/23					52,896	
4/26						
4/30					1,600	
5/ 3						
5/ 7						
5/11						
5/14						
5/17						
5/21			105,792			
5/24			3,200			3,200
5/27		3,200				
5/31						
6/ 3			3,200	6,400		
6/ 7				6,400		
6/11						3,200
6/16				6,400		105,792
6/18				3,200		
6/21				6,400		
6/25				158,688		
6/28			846,336	317,376		
7/ 3			211,584	2,226,336		1,600
7/ 5			12,800	793,440		
7/ 9			105,792	787,648		105,792
7/12			264,480	476,064		3,200
7/16			317,376	793,440		211,584
7/19			264,480	740,544		370,272
7/23			264,480	171,488		317,376
7/26			264,480	528,960		476,064
7/30			211,584	323,776		317,376
8/ 2		3,200	105,792	3,200		476,064
8/ 6		6,400	3,200	370,272		476,064
8/ 9			105,792	264,480		317,376
8/13	793,440		158,688	1,005,024		1,692,672
8/15			6,400	476,064		528,960
8/20	211,584		3,200	423,168		1,692,672
8/23	211,584		6,400	370,272		1,110,816
8/27	264,480			581,856		846,336
8/31	211,584			1,005,024		2,221,632
9/ 2	3,226,656		105,792	899,232		2,062,944
9/ 6	6,876,480			899,232		1,216,608

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Inactis tinctoria Agardh	Merismopedium glaucum	Microcystis sp	Nostoc sp	Oscillatoria formosa	Oscillatoria sp
9/ 9	5,130,912			264,480		899,232
9/13	5,501,184			846,336		1,216,608
9/17	4,231,680		317,376	423,168		105,792
9/20	6,876,480	105,792	158,688	264,480		1,110,816
9/24	6,559,104			476,064		370,272
9/27	4,337,472		52,896	52,896		740,544
10/ 1	2,433,216		105,792			370,272
10/ 4	2,221,632		105,792	158,688		105,792
10/ 8	1,428,192		52,896	158,688		317,376
10/11	1,163,712	52,896	105,792	6,400		105,792
10/15	1,216,608		6,400			528,960
10/18	476,064					105,792
10/22	846,336		6,400			370,272
10/26	105,792		52,896			
10/29	317,376		6,400	6,400		211,584
11/ 1	264,480	634,752	105,792	6,400		52,896
11/ 5		370,272	6,400	52,896		52,896
11/ 8	158,688	264,480	52,896			52,896
11/12	79,344	3,358,896				52,896
11/15	158,688	1,269,504	52,896			
11/19	52,896	528,960		3,200		52,896
11/22	52,896	634,752				158,688
11/26		634,752				
11/30		105,792	1,600			
12/ 3		343,824	3,200			52,896
12/ 6	1,600	211,584		1,600		79,344
12/10		92,568				26,448
12/14		132,240				33,060
12/17		238,032				33,060
12/20		105,792				39,672
12/24		33,060	400		800	13,224
12/27		99,180				52,896
12/31		79,344				13,224

1913	Oscillatoria tenuis	Phormidium spp	Stigonema sp	Total Schizophyceae	Actinastrum hantzschii	Actinastrum hantzschii (large)
1/ 5		13,224		14,024		
1/ 8	1,200			2,000		
1/12						
1/15						
1/19		400		800		
1/22	800	800		3,200	800	
1/26		26,848		27,248		
1/29		800		2,000		
2/ 2		13,624		14,824	400	
2/ 5		400		2,800		
2/ 8		39,672		40,472		
2/12		26,448		26,448		
2/15	26,448	370,272		396,720		
2/19		92,568		94,168	1,600	
2/23		238,032		277,704		
2/26		238,032		244,432		
3/ 1	3,200	79,344		85,744		
3/ 5		158,688		211,584		
3/ 8		318,976		318,976		
3/12						
3/15		158,688		213,184		
3/19	1,600	238,032		318,976	52,896	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Oscillatoria tenuis	Phormidium spp	Stigonema sp	Total Schizophyceae	Actinastrum hantzschii	Actinastrum hantzschii (large)
3/23	1,600	79,344		80,944	52,896	
3/26		238,032		290,928	1,600	
3/29		105,792		110,592		
4/ 2		158,688		163,488	3,200	
4/ 5		185,136		239,632		
4/ 9		158,688		175,688	1,600	
4/13		6,400		11,200		
4/16	52,896	264,480		322,176		
4/19	1,600	158,688		165,088		
4/23		79,344		185,136	52,896	
4/26		3,200		92,144		3,200
4/30				1,600		
5/ 3	185,136			267,680		3,200
5/ 7	1,600	1,600		14,400		3,200
5/11	52,896	52,896		160,288	3,200	
5/14	105,792			320,576		
5/17	317,376			323,776		
5/21	3,200		6,400	379,872		
5/24	370,272		3,200	488,864	6,400	
5/27	105,792	3,200		323,776		
5/31	158,688			168,288	3,200	3,200
6/ 3				1,391,296	105,792	3,200
6/ 7			6,400	884,736	3,200	
6/11	3,200			859,136		
6/16	3,200			461,568		
6/18	105,792			859,136	105,792	
6/21	3,200	158,688		1,226,208	3,200	
6/25	3,200	264,480		1,886,560	3,200	3,200
6/28	211,584	3,200		2,436,416		
7/ 3				3,127,168	105,792	
7/ 5	12,800			1,559,584	3,200	
7/ 9				2,164,240	3,200	
7/12	370,272			4,763,840	6,400	12,800
7/16				4,919,328		105,792
7/19				2,648,002		19,200
7/23	105,792			1,262,208		6,400
7/26				2,750,602	3,200	105,792
7/30				1,543,584		6,400
8/ 2	3,200			703,648		6,400
8/ 6				1,114,016		12,800
8/ 9	158,688			1,391,296		19,200
8/13	264,480	528,960		4,659,632		264,480
8/15	3,200		105,792	1,666,376		6,400
8/20	105,792	158,688	12,800	3,049,056		158,688
8/23		211,584		2,704,096	3,200	158,688
8/27		105,792		2,803,488	3,200	370,272
8/31	3,200			3,936,704		158,688
9/ 2	3,200	1,110,816		8,046,592		12,800
9/ 6	211,584	1,481,088		11,438,336		3,200
9/ 9	211,584	952,128		8,198,880		3,200
9/13	3,200	528,960		8,806,832	3,200	6,400
9/17		317,376		5,877,856		6,400
9/20		264,480		9,580,576	211,584	6,400
9/24	52,896	1,163,712		9,309,696		105,792
9/27		158,688		6,036,544	52,896	12,800
10/ 1		423,168		4,290,368	52,896	264,480
10/ 4		105,792		3,550,432		476,064
10/ 8	52,896	634,752		3,332,448		158,688
10/11	6,400	581,856		2,446,016		158,688
10/15	476,064	105,792		2,545,408		158,688

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Oscillatoria tenuis	Phormidium spp	Stigonema sp	Total Schizophyceae	Actinastrum hantzschii	Actinastrum hantzschii (large)
10/18	370,272	105,792		1,110,816		211,584
10/22	317,376	423,168		2,016,448	6,400	105,792
10/26	52,896			370,272		264,480
10/29	6,400			812,640	105,792	211,584
11/ 1				1,699,072		211,584
11/ 5	6,400			912,032		52,896
11/ 8				793,440		
11/12		52,896		4,284,576	1,600	
11/15				2,063,144	52,896	
11/19	52,896			1,008,224	105,792	
11/22	3,200	52,896		1,388,496	79,344	
11/26	1,600	52,896		689,248	132,240	52,896
11/30	79,344	1,600		347,024	52,896	
12/ 3	3,200	185,136		641,152	3,200	
12/ 6				297,328		
12/10	400	400		158,052		
12/14	800	400	1,600	260,668		
12/17	13,224	400		364,060	400	
12/20	105,792	400		264,880		400
12/24	400		800	89,156	400	
12/27	26,448			225,608		
12/31	13,224			145,464		

1913	Coelastrum microporum	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum	Richteriella botryoides
1/ 5		6,612	6,612			
1/ 8		800	400			
1/12			400			
1/15		400	400		400	
1/19		1,200	1,200			
1/22		1,600	4,800			
1/26			400			
1/29		800	19,836			
2/ 2		800	13,224			
2/ 5		3,200	2,400	13,224		
2/ 8		4,800	5,600			
2/12		4,800	6,400			
2/15			11,200			800
2/19		39,672	92,568	1,600	52,896	
2/23		26,448	26,448			
2/26		6,400	79,344	1,600		
3/ 1		6,400	3,200		79,344	
3/ 5			12,800			3,200
3/ 8		1,600	12,800	6,400		
3/12		9,600	6,400			
3/15	3,200	9,600	22,400		1,600	
3/19		79,344	132,240		1,600	
3/23		3,200	9,600		52,896	
3/26		9,600	16,000		1,600	
3/29		3,200	9,600		3,200	
4/ 2		12,800	6,400			
4/ 5	3,200	3,200	79,344	3,200	1,600	
4/ 9			6,400		6,400	
4/13		9,600	6,400		4,800	
4/16			16,000		79,344	
4/19			1,600		79,344	
4/23		1,600	3,200		132,240	
4/26			16,000		132,240	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Coelastrum microporum	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum	Richteriella botryoides
4/30		6,400	6,400		79,344	
5/ 3			3,200		105,792	
5/ 7			6,400		1,600	
5/11			105,792		107,392	1,600
5/14		6,400			108,992	
5/17		6,400	6,400		108,992	
5/21			19,200	6,400	158,688	
5/24		6,400	6,400		317,376	
5/27		3,200	12,800		264,480	
5/31	264,480		6,400		743,744	
6/ 3	158,688	105,792	12,800		211,584	
6/ 7		3,200	32,000		105,792	
6/11			158,688		317,376	
6/16			25,600		528,960	
6/18		3,200	6,400			
6/21	370,272		158,688		634,752	
6/25		3,200	317,376		264,480	3,200
6/28		6,400	370,272		3,200	
7/ 3			793,440		4,800	
7/ 5	6,400		476,064	3,200		
7/ 9	158,688	6,400	1,005,024		108,992	
7/12	158,688		1,269,504		3,200	
7/16	105,792		793,440	12,800	264,480	
7/19	105,792	12,800	740,544		3,200	
7/23	211,584		634,752	158,688	6,400	
7/26	476,064	6,400	793,440	19,200	267,680	
7/30	211,584		740,544	3,200	3,200	
8/ 2	105,792	3,200	476,064	6,400	105,792	
8/ 6	211,584	12,800	264,480		323,776	
8/ 9	211,584	3,200	793,440		3,200	
8/13	105,792		423,168	6,400	264,480	
8/15	211,584		317,376		3,200	
8/20	423,168		211,584		105,792	
8/23	634,752		476,064	3,200	211,584	
8/27	528,960	3,200	105,792		6,400	
8/31	634,752		105,792		370,272	
9/ 2	1,005,024	12,800	634,752	6,400	479,264	
9/ 6	2,221,632		634,752	211,584	211,584	105,792
9/ 9	2,697,696	105,792	687,648	105,792	264,480	
9/13	3,544,032	105,792	476,064		264,480	
9/17	1,163,712	6,400	423,168	12,800	267,680	
9/20	793,440	6,400	740,544		211,584	
9/24	264,480	12,800	1,851,360	25,600	317,376	
9/27	476,064		793,440	6,400	317,376	
10/ 1	423,168		952,128	6,400	317,376	
10/ 4	317,376	12,800	1,110,816	19,200	370,272	52,896
10/ 8	158,688	105,792	1,798,464	6,400	376,672	
10/11	211,584	12,800	2,010,048		171,488	
10/15	52,896		1,533,984			
10/18			476,064		158,688	52,896
10/22	158,688	6,400	740,544	52,896		105,792
10/26	12,800		793,440			52,896
10/29	211,584	19,200	846,336	12,800	264,480	52,896
11/ 1	158,688	6,400	528,960	6,400	317,376	52,896
11/ 5	52,896	12,800	952,128		6,400	
11/ 8		6,400	158,688	52,896	370,272	
11/12	52,896	52,896	317,376		872,784	
11/15	264,480	52,896	6,400		423,168	
11/19	79,344	12,800	52,896		158,688	
11/22	28,800	6,400	238,032		105,792	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Coelastrum microporum	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum	Richteriella botryoides
11/26	6,400	6,400	32,000		79,344	
11/30	52,896	1,600	79,344		1,600	
12/ 3	79,344	3,200	52,896		105,792	
12/ 6	3,200	1,600	19,200		54,496	
12/10	800	800	19,836		59,908	
12/14	800	800	33,060		13,224	400
12/17			400		53,296	
12/20			13,224	800	46,284	
12/24		1,600	13,224		13,224	
12/27		1,600	39,672		119,016	
12/31			33,060		85,956	

1913	Scenedesmus obliquus	Scenedesmus quadricauda	Schroederia setigera	Selenastrum bibraianum	Stigeoclonium sp	Ulothrix sp
1/ 5	6,612					
1/ 8						
1/12						
1/15	400					
1/19		400				
1/22		33,060		400		
1/26	13,224			400		
1/29		400				
2/ 2		400				
2/ 5		13,224				
2/ 8		800				
2/12		1,600		800		
2/15		52,896		52,896		
2/19	800	52,896				
2/23	800	39,672				
2/26		132,240				
3/ 1	3,200	6,400				
3/ 5	1,600	79,344				
3/ 8		6,400				
3/12		52,896				
3/15		132,240				
3/19		3,200				
3/23		105,792				3,200
3/26		3,200				
3/29		3,200				
4/ 2		6,400				
4/ 5		105,792			3,200	3,200
4/ 9	1,600	79,344				
4/13		6,400				
4/16		158,688				
4/19		52,896				
4/23		132,240				
4/26	6,400	132,240				
4/30	52,896	52,896	1,600			
5/ 3		1,600				
5/ 7	79,344	52,896	1,600			
5/11	1,600	185,136				
5/14		317,376				
5/17	3,200	19,200	3,200			
5/21	264,480	264,480				
5/24	211,584	1,057,920	3,200			
5/27	423,168	1,216,608	105,792			
5/31	1,322,400	3,385,344	105,792			
6/ 3	2,591,904	2,539,008	105,792			

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Scenedesmus obliquus	Scenedesmus quadricauda	Schroederia setigera	Selenastrum bibraianum	Stigeoclonium sp	Ulothrix sp
6/ 7	1,957,152	2,697,696	317,376			
6/11	634,752	1,533,984	158,688			
6/16	423,168	1,110,816	3,200			
6/18	634,752	1,745,568	264,480			
6/21	370,272	2,909,280	264,480	3,200		
6/25	899,232	2,803,488	105,792			
6/28	1,110,816	2,803,488	105,792			
7/ 3	740,544	1,163,712	158,688			
7/ 5	158,688	370,272			3,200	
7/ 9	211,584	634,752				
7/12	211,584	476,064				
7/16	423,168	1,375,296				
7/19	528,960	952,128				
7/23	105,792	581,856	105,792			
7/26	687,648	1,005,024	105,792			
7/30	317,376	634,752	3,200			
8/ 2	105,792	899,232	3,200			
8/ 6	158,688	634,752				
8/ 9		581,856				
8/13	370,272	1,639,776	264,480			
8/15	264,480	899,232				
8/20	211,584	581,856				
8/23	423,168	1,110,816	3,200			
8/27	528,960	1,216,608				
8/31	423,168	846,336				
9/ 2	581,856	1,322,400				
9/ 6	476,064	1,057,920				
9/ 9	528,960	1,163,712				
9/13	476,064	1,533,584				
9/17	370,272	1,163,712				
9/20	687,648	1,428,192				
9/24	264,480	1,586,880	52,896			
9/27	528,960	1,639,776	52,896			
10/ 1	1,057,920	2,062,944				
10/ 4	740,544	1,533,984				
10/ 8	581,856	1,428,192				
10/11	1,057,920	952,128	105,792			
10/15	687,648	1,269,504	52,896			
10/18	687,648	1,057,920				
10/22	687,648	1,375,296	52,896			
10/26	793,440	1,533,984				
10/29	1,428,192	1,957,152	264,480			
11/ 1	687,648	2,115,840	105,792			
11/ 5	1,005,024	3,438,240	6,400			
11/ 8	158,688	899,232	105,792			
11/12	899,232	2,644,800	317,376			
11/15	476,064	1,163,712	317,376			
11/19	185,136	846,336				
11/22	290,928	925,680				
11/26	185,136	370,272	1,600			
11/30	158,688	661,200	1,600			
12/ 3	317,376	185,136				
12/ 6	16,000	396,720				
12/10	19,836	112,404				
12/14	99,180	211,584	13,224			
12/17	52,896	132,240	400			
12/20	66,120	178,528	26,448			
12/24	13,224	66,120	13,224			
12/27	26,448	99,180	13,224			
12/31	19,836	132,240	19,836			

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Total Chlorophyceae	Asterionella gracillima	Asterionella gracillima (large)	Amphiprora alata	Bacillaria paradoxa	Cocconeis pediculus
1/ 5	19,836	707,484			6,612	
1/ 8	1,200	257,868				
1/12	400	528,960				
1/15	1,600	2,254,692	19,836			
1/19	2,800	4,350,696	400	13,224		
1/22	40,660	740,544			46,284	
1/26	14,024	238,032				
1/29	21,036	1,071,144			1,600	
2/ 2	14,824	1,031,472			6,400	
2/ 5	32,448	985,188		13,224		
2/ 8	11,200	1,044,696				
2/12	13,600	251,256		52,896		
2/15	117,792	859,560		26,448		
2/19	242,032	1,097,592		26,448		
2/23	93,368	370,272		800		
2/26	219,584	4,496,616				1,600
3/ 1	98,544	528,960		3,200		
3/ 5	96,944	290.928				
3/ 8	27,200	132,240				
3/12	68,896					
3/15	169,040	370,272		1,600		
3/19	279,280	132,240		1,600		
3/23	224,384	185,136	6,612	1,600		
3/26	32,000	158,688				
3/29	19,200	581,856				
4/ 2	28,800	79,344			3,200	
4/ 5	196,336	105,792		1,600	3,200	
4/ 9	96,944	105,792	26,448	1,600		
4/13	25,600	16,000	1,600	1,600	3,200	
4/16	255,632	105,792				
4/19	133,840	26,448				
4/23	375,072	132,240				
4/26	290,080	132,240				
4/30	201,136					
5/ 3	113,792	1,600				
5/ 7	145,040	502,512				
5/11	404,720	52,896	714,096	1,600		
5/14	432,768	105,792	264,480			
5/17	147,392	211,584	370,272			
5/21	713,248	211,584	3,200			
5/24	1,873,760	12,800		3,200		
5/27	2,026,048	158,688	3,200	158,688		
5/31	5,834,560			3,200		
6/ 3	5,829,760	158,688	3,200			
6/ 7	5,116,416	105,792				
6/11	2,803,488	211,584	105,792			
6/16	1,091,744	423,168	423,168	3,200		
6/18	2,750,192	528,960	476,064			
6/21	4,714,144	423,168	264,480			
6/25	4,603,168	476,064	158,688	105,792		
6/28	4,399,968	634,752	264,480	3,200		
7/ 3	2,966,976	105,792	3,200			
7/ 5	1,021,024			3,200		
7/ 9	2,131,840					
7/12	2,138,232			3,200		
7/16	3,080,768				12,800	
7/19	2,362,624			6,400	57,600	
7/23	1,811,264					
7/26	3,470,240			3,200	211,584	
7/30	1,920,256			3,200		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Total Chlorophyceae	Asterionella gracillima	Asterionella gracillima (large)	Amphiprora alata	Bacillaria paradoxa	Cocconeis pediculus
8/ 2	1,710,872				32,000	
8/ 6	1,618,880				3,200	
8/ 9	1,612,480					
8/13	3,338,948	3,200			6,400	
8/15	1,702,272				12,800	
8/20	1,692,672	105,792				
8/23	3,024,672				25,600	
8/27	2,763,392				105,792	
8/31	2,538,988				25,600	
9/ 2	4,048,296				6,400	
9/ 6	4,922,528				6,400	
9/ 9	5,557,280			3,200	6,400	
9/13	6,410,016			3,200	6,400	
9/17	3,414,944			105,792		
9/20	3,085,784			52,896	52,896	
9/24	4,481,664				6,400	
9/27	3,880,608			52,896	52,896	
10/ 1	5,137,312				12,800	
10/ 4	4,633,952				32,000	
10/ 8	4,667,636				6,400	52,896
10/11	4,680,448					
10/15	3,755,616			52,896	6,400	
10/18	2,591,904					
10/22	3,312,352			105,792	6,400	
10/26	3,451,040			52,896		52,896
10/29	5,324,496	52,896		12,800		
11/ 1	4,191,584			105,792		
11/ 5	5,526,784	52,896		158,688		
11/ 8	1,851,968					
11/12	5,211,856			1,600		
11/15	2,809,888					
11/19	1,441,592	79,344	79,344	1,600		
11/22	1,674,976	3,200	9,600	52,896	9,600	
11/26	866,288			1,600		
11/30	1,009,824		1,600		6,400	
12/ 3	746,944	1,507,536	1,600			
12/ 6	491,216	1,401,744	52,896	1,600	52,896	
12/10	213,584	614,916		400	800	
12/14	372,272	198,360	390,108	39,672	19,836	
12/17	239,632	185,136	400	13,224		
12/20	331,800	105,792		26,448	26,448	800
12/24	121,016	85,956		13,224	2,400	400
12/27	299,140	59,508		33,060	800	
12/31	290,928	19,836			4,000	

1913	Cyclotella spp	Cymatopleura solea	Cymbella affinis	Cymbella cymbiformis	Cymbella parva	Cymbella sp
1/ 5	257,868					
1/ 8	106,592					
1/12	317,376					
1/15	793,440					
1/19	1,573,656					
1/22	449,616					800
1/26	204,972					
1/29	257,868					
2/ 2	158,688					
2/ 5	357,048					800
2/ 8	304,152					

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cyclotella spp	Cymatopleura solea	Cymbella affinis	Cymbella cymbiformis	Cymbella parva	Cymbella sp
2/12	740,544			1,600		
2/15	1,150,488					800
2/19	1,401,744			1,600		
2/23	886,008					
2/26	3,570,480					3,200
3/ 1	5,210,256					
3/ 5	5,659,872	3,200				
3/ 8	1,613,328		1,600	3,200		
3/12	2,697,696					
3/15	1,110,816					
3/19	2,168,736					
3/23	2,724,144			3,200		1,600
3/26	1,163,712					
3/29	925,680					
4/ 2	925,680				3,200	
4/ 5	2,459,664				1,600	
4/ 9	6,162,384					
4/13	3,570,480	3,200				
4/16	9,151,008					
4/19	10,684,992					
4/23	15,472,080					
4/26	15,286,944					
4/30	18,116,880					
5/ 3	20,391,408			3,200		
5/ 7	19,597,968					
5/11	32,610,384		1,600			
5/14	60,248,544					
5/17	43,216,032					
5/21	36,022,176					
5/24	35,704,800					
5/27	54,482,880					
5/31	53,001,792		3,200			
6/ 3	57,286,368					
6/ 7	60,195,648					
6/11	59,349,312		105,792	3,200		
6/16	38,508,288					3,200
6/18	42,475,488					
6/21	34,646,880					
6/25	36,974,304					
6/28	51,362,016			6,400		
7/ 3	35,175,840					
7/ 5	14,281,920					
7/ 9	12,324,768					
7/12	16,768,032					
7/16	45,755,040					
7/19	24,279,264					
7/23	11,742,912			6,400		
7/26	17,349,888		3,200			
7/30	15,168,800					
8/ 2	14,916,672					
8/ 6	9,838,656					
8/ 9	10,790,784					
8/13	14,229,024					
8/15	6,770,688					
8/20	12,113,184					
8/23	14,440,608					
8/27	20,047,584					
8/31	21,898,944					
9/ 2	12,166,080					
9/ 6	12,166,080					

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cyclotella spp	Cymatopleura solea	Cymbella affinis	Cymbella cymbiformis	Cymbella parva	Cymbella sp
9/ 9	12,166,080		3,200			
9/13	15,128,256					
9/17	14,493,504					
9/20	13,065,312					
9/24	14,757,984					
9/27	19,677,312					
10/ 1	21,687,360					
10/ 4	12,695,040					
10/ 8	18,090,432	6,400				
10/11	22,851,072					
10/15	20,788,128					
10/18	25,866,144					
10/22	28,246,464			6,400		
10/26	34,276,608					
10/29	31,853,392			6,400		
11/ 1	12,589,248	6,400				
11/ 5	9,203,904					
11/ 8	7,775,712		6,400			
11/12	11,240,400		1,600			
11/15	7,722,816					
11/19	7,061,616		3,200	3,200		
11/22	7,697,968	3,200	3,200			
11/26	6,692,944					
11/30	6,876,480					
12/ 3	6,955,824					
12/ 6	4,522,608					
12/10	1,970,376		400			
12/14	2,281,140					
12/17	2,499,336					
12/20	2,737,368					800
12/24	1,283,128	400		800		
12/27	2,876,220			800		
12/31	1,838,136					

1913	Cymbella tumida	Diatom unidentified	Diatoma vulgare	Epithemia ocellata	Fragillaria capucina	Fragillaria crotonensis
1/ 5						
1/ 8						
1/12						
1/15					800	
1/19					800	
1/22				400		
1/26		400				
1/29						
2/ 2						
2/ 5					800	
2/ 8						
2/12		26,448				
2/15					1,600	
2/19		800			1,600	
2/23	800				800	
2/26					1,600	
3/ 1					3,200	
3/ 5						
3/ 8				3,200		
3/12						
3/15					6,400	
3/19	3,200	1,600			1,600	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cymbella tumida	Diatom unidentified	Diatoma vulgare	Epithemia ocellata	Fragillaria capucina	Fragillaria crotonensis
3/23	3,200	1,600			3,200	
3/26		1,600			3,200	
3/29					3,200	
4/ 2					3,200	
4/ 5					1,600	
4/ 9						
4/13	3,200				3,200	
4/16		1,600			1,600	
4/19		1,600				
4/23		1,600				
4/26	1,600				6,400	3,200
4/30	52,896				1,600	
5/ 3					3,200	
5/ 7					3,200	
5/11						
5/14	6,400					
5/17	25,200					
5/21						
5/24						
5/27				6,400		
5/31						
6/ 3						
6/ 7		6,400	3,200			
6/11						
6/16				6,400		
6/18						
6/21						
6/25					6,400	
6/28						
7/ 3						
7/ 5						
7/ 9						
7/12						
7/16	6,400			6,400		
7/19						
7/23					6,400	
7/26						
7/30						
8/ 2				6,400		
8/ 6					12,800	
8/ 9					6,400	
8/13				3,200		
8/15						
8/20					3,200	
8/23						
8/27	6,400			6,400		
8/31			3,200			
9/ 2						
9/ 6					6,400	
9/ 9				6,400		
9/13				6,400		
9/17				6,400	3,200	
9/20						
9/24						
9/27						
10/ 1						
10/ 4						
10/ 8					6,400	
10/11						
10/15	105,792	105,792		6,400		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cymbella tumida	Diatom unidentified	Diatoma vulgare	Epithemia ocellata	Fragilaria capucina	Fragilaria crotonensis
10/18						.
10/22						.
10/26	6,400					
10/29						6,400
11/ 1				6,400		
11/ 5				6,400	6,400	
11/ 8	6,400					
11/12						
11/15				6,400		
11/19				3,200		
11/22				3,200	3,200	
11/26					3,200	
11/30				6,400	3,200	
12/ 3				6,400		
12/ 6	1,600					
12/10	1,600					
12/14						
12/17						
12/20	800			400		
12/24						
12/27	800			800		
12/31	800			1,600		

1913	Fragilaria sp	Gomphonema constrictum	Gomphonema sp	Gyrosigma acuminatum	Gyrosigma kutzingii	Gyrosigma scalproides
1/ 5					6,612	
1/ 8						
1/12						
1/15						
1/19						
1/22					400	
1/26						
1/29						
2/ 2						
2/ 5						
2/ 8						
2/12						800
2/15						
2/19						
2/23						
2/26						1,600
3/ 1						
3/ 5					1,600	
3/ 8						
3/12						
3/15						
3/19						
3/23						
3/26				52,896		
3/29						
4/ 2					1,600	
4/ 5						
4/ 9		1,600				
4/13				3,200		
4/16			1,600			
4/19						
4/23					1,600	
4/26						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Fragilaria sp	Gomphonema constrictum	Gomphonema sp	Gyrosigma acuminatum	Gyrosigma kutzingii	Gyrosigma scalproides
4/30						
5/ 3						
5/ 7					1,600	
5/11					52,896	
5/14						
5/17	6,400				3,200	
5/21						
5/24						3,200
5/27						
5/31				3,200		
6/ 3						
6/ 7						
6/11						
6/16						
6/18						
6/21						
6/25						3,200
6/28						
7/ 3						
7/ 5						
7/ 9						
7/12						
7/16						
7/19						
7/23						
7/26						
7/30						
8/ 2					25,600	
8/ 6						
8/ 9						3,200
8/13						158,688
8/15				6,400		264,480
8/20						3,200
8/23					3,200	6,400
8/27						158,688
8/31					3,200	105,792
9/ 2	3,200					158,688
9/ 6				6,400	105,792	12,800
9/ 9					6,400	
9/13					6,400	6,400
9/17		3,200				6,400
9/20						105,792
9/24						105,792
9/27						52,896
10/ 1				52,896		
10/ 4					25,600	
10/ 8		52,896			12,800	
10/11					6,400	6,400
10/15		52,896				105,792
10/18						105,792
10/22					12,800	
10/26					12,800	
10/29						
11/ 1						
11/ 5						
11/ 8					52,896	
11/12						
11/15						
11/19			3,200			
11/22						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Fragilaria sp	Gomphonema constrictum	Gomphonema sp	Gyrosigma acuminatum	Gyrosigma kutzingii	Gyrosigma scalproides
11/26					1,600	
11/30					3,200	1,600
12/ 3			1,600			1,600
12/ 6						
12/10					800	1,600
12/14		400				800
12/17						400
12/20						
12/24					800	13,224
12/27		13,224	400		400	19,836
12/31		13,224				13,224

1913	Melosira granulata	Melosira granulata A (small)	Melosira varians	Navicula affinis	Navicula alpestris	Navicula bacillum
1/ 5	19,836		26,448			
1/ 8	26,448					
1/12	2,400					
1/15	13,224					
1/19	26,448		2,800			
1/22	1,322,400		800		800	
1/26	33,060					
1/29	125,628		800			
2/ 2	72,732					
2/ 5	204,972		400			
2/ 8	132,240					
2/12	145,464					
2/15	304,152		1,600			
2/19	542,184		3,200	1,600		
2/23	119,016		26,448			
2/26	476,064		3,200			
3/ 1	343,824					
3/ 5	132,240		3,200			
3/ 8	264,480		3,200			
3/12	158,688					
3/15	793,440		6,400		52,896	
3/19	1,031,472		79,344		52,896	
3/23	793,440		6,400			
3/26	476,064	185,136	3,200			
3/29	502,512	317,376	9,600			
4/ 2	502,512	211,584	132,240			52,896
4/ 5	132,240		1,600			
4/ 9	634,752		52,896			
4/13	952,128		6,400		1,600	
4/16	872,784	317,376				
4/19	528,960					
4/23	2,274,528	238,032	1,600		1,600	52,896
4/26	3,702,720	1,600	9,600			3,200
4/30	449,616				1,600	52,896
5/ 3	449,616	52,896				
5/ 7	343,824	1,600	3,200		1,600	1,600
5/11	343,824		3,200		52,896	105,792
5/14	581,856	211,584				105,792
5/17	1,269,504	158,688	6,400		3,200	105,792
5/21	1,163,712		3,200			
5/24	1,005,024	105,792	3,200			3,200
5/27	1,375,296	317,376				211,584
5/31	317,376	105,792			3,200	158,688
6/ 3	634,752	105,792				105,792

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Melosira granulata	Melosira granulata A (small)	Melosira varians	Navicula affinis	Navicula alpestris	Navicula bacillum
6/ 7	528,960				3,200	
6/11	370,272					211,584
6/16	1,322,400					264,480
6/18	1,375,296					211,584
6/21	634,752				6,400	
6/25	2,062,944					3,200
6/28	7,617,024		6,400			158,688
7/ 3	3,067,968		6,400			3,200
7/ 5	1,005,024					3,200
7/ 9	1,481,088					
7/12	2,697,696					3,200
7/16	1,586 880					105,792
7/19	2,168,736					
7/23	1,428,192					
7/26	2,962,176					
7/30	2,539,008					
8/ 2	3,914,304					3,200
8/ 6	3,385,344					
8/ 9	4,972,224					
8/13	10,314,720				3,200	105,792
8/15	10,103,136				3,200	3,200
8/20	5,342,496				6,400	158,688
8/23	4,760,640					211,584
8/27	6,083,040					105,792
8/31	8,357,568					3,200
9/ 2	7,828,608					211,584
9/ 6	16,556,448					158,688
9/ 9	10,420,512					264,480
9/13	5,025,120					370,272
9/17	8,251,776					105,792
9/20	8,410,464					105,792
9/24	15,604,320			52,896	105,792	105,792
9/27	5,183,808					264,480
10/ 1	8,145,984				6,400	264,480
10/ 4	5,236,704					52,896
10/ 8	8,040,192				52,896	52,896
10/11	5,289,600		6,400		105,792	
10/15	7,828,608				6,400	264,480
10/18	4,601,952				52,896	158,688
10/22	4,654,848					
10/26	3,544,032				52,896	52,896
10/29	2,750,592				52,896	211,584
11/ 1	2,010,048					
11/ 5	1,798,464				52,896	52,896
11/ 8	899,232					264,480
11/12	1,137,264					1,600
11/15	1,005,024					105,792
11/19	740,544					52,896
11/22	978,576					52,896
11/26	1,137,264					
11/30	1,084,368				1,600	52,896
12/ 3	1,745,568		3,200			1,600
12/ 6	1,057,920				1,600	
12/10	350,436		2,400			33,060
12/14	257,868		400			400
12/17	337,212					33,060
12/20	370,272		800		400	19,836
12/24	271,092		800		800	39,672
12/27	588,468		26,448		400	
12/31	925,680	. . . .	33,060	. .	13,224	46,284

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Navicula dubia	Navicula gracilis	Navicula sp	Navicula viridis	Nitzschia acicularis	Nitzschia angularis
1/ 5						
1/ 8					400	
1/12			400			
1/15			13,224	400	13,224	
1/19			33,060		13, 24	
1/22				800	400	
1/26		400			13,224	
1/29					26,848	
2/ 2		13,224			19,836	
2/ 5		13,224			13,224	
2/ 8		800			27,248	
2/12		39,672			26,448	
2/15		800			26,448	
2/19		39,672			120,616	
2/23		39,672	800			
2/26		1,600			3,200	
3/ 1		1,600			107,392	
3/ 5			52,896			
3/ 8		1,600	3,200		3,200	
3/12		52,896	52,896		3,200	
3/15		105,792			1,600	
3/19		1,600			79,344	
3/23		105,792			1,600	
3/26		105,792			79,344	
3/29		52,896			1,600	
4/ 2		79,344			79,344	
4/ 5			52,896			
4/ 9		105,792	1,600			
4/13		1,600			4,800	
4/16		52,896	1,600		80,944	
4/19		52,896			1,600	
4/23					211,584	
4/26		52.896	1,600		185,136	
4/30		79,344			264,480	
5/ 3					79,344	
5/ 7		1,600			317,376	
5/11		52,896			290,928	
5/14		105,792			952,128	
5/17		158,688	3,200		1,533,984	6,400
5/21		3,200			2,644,800	
5/24		264,480		6,400	5,289,600	
5/27					15,181,152	
5/31		317,376			20,999,712	
6/ 3		264,480			23,221,344	
6/ 7		3,200			11,055,264	
6/11		3,200			11,108,160	
6/16		105,792			13,752,960	
6/18		211,584			19,624,416	
6/21		370,272			14,969,568	6,400
6/25		158,688			11,901,600	
6/28		211,584			11,108,160	
7/ 3		211,584			10,050,240	
7/ 5					4,284,576	
7/ 9		3,200		3,200	2,909,280	
7/12					4,866,432	
7/16		370,272			5,035,120	
7/19		211,584			4,125,888	
7/23		3,200			2,380,320	
7/26		423,168			6,982,272	
7/30		370,272			3,755,616	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Navicula dubia	Navicula gracilis	Navicula sp	Navicula viridis	Nitzschia acicularis	Nitzschia angularis
8/ 2	6,400	264,480			3,385,344	
8/ 6		158,688			3,702,720	
8/ 9	3,200	264,480			3,279,552	
8/13		2,539,008			6,453,312	
8/15		952,128			1,586,880	
8/20		1,269,504			634,752	
8/23		1,110,816			1,005,024	
8/27	3,200	793,440			2,539,008	
8/31		1,322 400			4,760,640	
9/ 2		1,163,712			5,236,704	
9/ 6	3,200	846,336			3,596,928	
9/ 9		846,336			2,115,840	
9/13		476,064			1,904,256	
9/17		370,272			2,010,048	
9/20		846,336			2,750,592	
9/24		899,232			3,332,448	
9/27		476,064	52,896		2,750,592	
10/ 1		528,960			3,120,864	
10/ 4					1,533,984	
10/ 8		52,896			1,745,568	
10/11		264,480			1,904,256	
10/15		158,688			2,062,944	
10/18		158,688			2,221,632	
10/22	52,896	52,896			2,062,944	
10/26		158,688			1,163,712	
10/29		105,792			1,745,568	
11/ 1					1,322,400	
11/ 5					1,005,024	
11/ 8					1,322,400	
11/12		52,896			3,173,760	
11/15					1,851,360	
11/19		79,344		3,200	1,719,120	
11/22		105,792			2,062,944	
11/26		79,344			2,036,496	
11/30		105,792			2,062,944	
12/ 3					1,163,712	
12/ 6		105,792		3,200	1,666,224	3,200
12/10		19,836			568,632	
12/14		46,284			416,556	
12/17		39,672			310,764	
12/20	800	46,284			138,852	
12/24		46,284			119,016	
12/27		66,120			145,464	
12/31		92,568		400	79,344	

1913	Nitzschia sigma	Nitzschia sigmoidea	Nitzschia vermicularis	Pleurostauron parvulum	Stauroneis phoenicenteron	Stephonodiscus sp.
1/ 5				6,612		
1/ 8			400	800		
1/12				400		
1/15				26,448		
1/19			400	39,672		
1/22	19,836			26,448	800	400
1/26				26,448		
1/29				26,448		
2/ 2				400		
2/ 5				46,284	800	
2/ 8				26,448		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Nitzschia sigma	Nitzschia sigmoidea	Nitzschia vermicularis	Pleurostauron parvulum	Stauroneis phoenicenteron	Stephonodiscus sp
2/12						
2/15			1,600	26,448		
2/19		3,200		39,672		
2/23	800			800		
2/26				1,600		
3/ 1			1,600	52,896		
3/ 5				52,896		
3/ 8		1,600		79,344		
3/12				79,344		
3/15				105,792		
3/19				105,792		
3/23				132,240		
3/26						
3/29				1,600		
4/ 2				1,600		
4/ 5				79,344		
4/ 9						
4/13				1,600		
4/16				158,688		
4/19				158,688		
4/23	1,600			52,896		
4/26				79,344		
4/30				52,896		
5/ 3				52,896		3,200
5/ 7				79,344		
5/11		1,600		1,600		
5/14				158,688		
5/17	6,400			211,584	6,400	
5/21				105,792		
5/24				211,584		
5/27	6,400				3,200	105,792
5/31						
6/ 3				3,200		
6/ 7				3 200		
6/11				3,200		
6/16	6,400			211,584		
6/18				3,200		
6/21						
6/25				105,792		
6/28						
7/ 3		3,200				
7/ 5						
7/ 9						
7/12						
7/16						
7/19						
7/23						
7/26						
7/30						
8/ 2	6,400					
8/ 6						
8/ 9	3,200					
8/13						
8/15						
8/20	3,200					
8/23				3,200		
8/27						
8/31		400				
9/ 2						
9/ 6	3,200			105,792		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Nitzschia sigma	Nitzschia sigmoidea	Nitzschia vermicularis	Pleurostauron parvulum	Stauroneis Phoenicenteron	Stephonodiscus sp
9/ 9			6,400			
9/13			6,400			
9/17						
9/20			6,400			
9/24	105,792		6,400			
9/27	52,896					
10/ 1				105,792		
10/ 4						
10/ 8			19,200			
10/11	6,400			52,896		
10/15	12,800		12,800			
10/18	52,896		52,896			
10/22				52,896		
10/26				105,792		
10/29				52,896		
11/ 1						
11/ 5	12,800			52,896		
11/ 8						
11/12				79,344		
11/15			6,400			
11/19				52 896		
11/22	3,200		1,600			
11/26				1,600		
11/30	3,200			105,792		
12/ 3	3,200			1,600		
12/ 6			3,200			
12/10	800			33,060		
12/14	19,836			26,448		
12/17	800			19,836		
12/20	39,672			33,060	400	
12/24	800			400		
12/27	39,672			26,448	400	
12/31			800	26,448		

1913	Surirella sp	Synedra radians	Synedra ulna	Total Bacillariaceae	Closterium acerosum	Closterium rostratum
1/ 5			132,240	1,163,712		
1/ 8			59,508	452,016		
1/12			66,120	915,656		
1/15			138,852	3,275,140		
1/19			198,360	6,253,140		
1/22	3,200		211,584	2,858,572	400	
1/26			257,868	774,404	400	
1/29	400		251,256	1,761,992		
2/ 2			152,076	1,454,828		
2/ 5	1,600		310,764	1,948,328		
2/ 8	800		132,240	1,668,624	1,600	
2/12			370,272	1,656,200		
2/15	800		436,092	2,837,136		
2/19	4 800		357,048	3 641,776		
2/23	3,200		317,376	1,766,792		
2/26	6,400		528,960	5 049,120		
3/ 1			581,856	6,834,784		
3/ 5	3,200		211,584	6,621,600		
3/ 8			238,032	2,348,224		
3/12	3,200		158,688	3,206,608		
3/15			370,272	2,925,280		
3/19	3,200		290,928	4,263,892		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Surirella sp	Synedra radians	Synedra ulna	Total Bacillariaceae	Closterium acerosum	Closterium rostratum
3/26			396,720	2,441,216		
3/29	12,800		105,792	2 567,808		
4/ 2	3,200		264,480	2,343,424		
4/ 5			370,272	3,209,808		
4/ 9	3,200		185,136	7,360,544		
4/13	52,896		79,344	4,706,048		
4/16			396,720	11,142,608		
4/19			158,688	11,613,872		
4/23			714,096	19,156,352		
4/26	3,200		132,240	19,654,816		
4/30			132,240	19,204,448		
5/ 3	6,400		581,856	21,622,416		
5/ 7			290,928	21,166,352		
5/11	1,600		132,240	34,420,048		
5/14	6,400		687,648	63,435,104		
5/17	211,584		2,010,048	49,630,352		
5/21			687,648	40,739,520		
5/24	19,200		423,168	43,227,536		
5/27	25,600		1,957,152	74,204,992		
5/31	3,200		1,110,816	75,971,456		3,200
6/ 3			846,336	82,633,152		
6/ 7			1,375,296	73,280,160		
6/11			1,110,816	72,582,912		
6/16	6,400		899,232	55,939,872		
6/18	6,400		1,110,816	66,023,808		
6/21			476,064	51,797,984		
6/25			1,692,672	53,755,136		
6/28	3,200		2,856,384	74,338,080	6,400	
7/ 3			1,533,984	50,161,408		
7/ 5			423,168	20,001,088		
7/ 9	6,400		476,064	17,204,000		
7/12			423,168	24,761,728		
7/16	3,200	4,496,160	634,792	58,002,816		
7/19		634,752	317,376	31,801,600		
7/23	3,200	581,856	528,960	16,675,040		
7/26	105,792	899,232	687,648	29,637,760		
7/30	6,400	423,168	528,960	23,495,424	6,400	3,200
8/ 2		370,272	423,168	23,354,240		
8/ 6		634,752	423,168	18,159,328	6,400	105,792
8/ 9	105,792	1,005,024	528,960	20,966,016		211,584
8/13	6,400	2,750,592	2,062,944	39,059,648	3,200	423 168
8/15	6,400	740,544	1,005,024	21,613,568	6,400	19,200
8/20	6,400	846,336	952,128	21,815,552		105,792
8/23		740,544	1,375,296	31,965,184		6,400
8/31	12,800	2,115,840	1,375,296	39,987,680		105,792
9/ 2	6,400	1,481,088	1,322,400	29,588,064		211,584
9/ 6	12,800	634,752	2,539,008	36,761,024	3,200	264,480
9/ 9		687,648	1,057,920	27,590,816		3,200
9/13	158,688	740,544	1,533,984	25,372,384		6,400
9/17		687,648	687,648	26,731,680		105,792
9/20		952,128	846,336	27,194,944		105,792
9/24	19,200	1,639,776	793,440	37,535,264		52,896
9/27	52,896	1,322,400	423,168	30,415,200		6,400
10/ 1	6,400	1,692,672	1,216,608	36,841,216	6,400	6,400
10/ 4	52,896	1,375,296	1,375,296	22,379,712		
10/ 8	19,200	1,481,088	1,216,608	30,908,768		
10/11	12,800	1,692,672	1,375,296	33,574,464		6,400
10/15	158,688	1,269,504	2,803,488	35,802,496		52,896
10/18	19,200	1,005,024	1,322,400	35,512,416	6,400	
10/22		1,269,504	846,336	37,370,176	6,400	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Surirella sp	Synedra radians	Synedra ulna	Total Bacillariaceae	Closterium acerosum	Closterium rostratum
10/26	6,400	846,336	528,960	40,861,312		
10/29	12,800	793,440	793,440	38,450,896		105,792
11/ 1	105,792	740,544	211,584	17,098,208		
11/ 5	6,400	528,960	528,960	13,467,584		
11/ 8	6,400	634,752	264,480	11,233,152		
11/12	1,600	1,243,056	476,064	17,409,184		52,896
11/15		158,688	105,792	10,962,272		
11/19	3,200	290,928	370,272	10,547,104		6,400
11/22	52,896	79,344	423,168	11,546,480		
11/26	3,200	132,240	211,584	10,301,072		1,600
11/30	3,200	158,688	396,720	10,874,080		1,600
12/ 3		79,344	925,680	12,398,464		1,600
12/ 6	6,400	1,600	158,688	9,041,168		3,200
12/10		39,672	113,204	3,751,992	1,600	
12/14	800	52,896	191,784	3,943,552		
12/17	400	33,060	125,628	3,598,928	800	400
12/20	4,000	52,896	370,272	3,976,400		
12/24	19,836	33,060	138,852	2,071,744		
12/27	46,284	46,284	621,528	4,627,788		
12/31	26,448	26,448	509,124	3,671,048		

1913	Closterium sp	Mougeotia sp	Staurastrum A	Straurastrum sp	Total Conjugatae	Total Algae
1/ 5						1,197,572
1/ 8	400				400	456,016
1/12					400	916,456
1/15						3,277,140
1/19						6,283,188
1/22			800		21,036	2,923,468
1/26					800	816,476
1/29						1,785,028
2/ 2						1,484,476
2/ 5						1,963,576
2/ 8					1,600	1,721,896
2/12	800				800	1,697,048
2/15		800			1,600	3,354,048
2/19			1,600		1,600	3,979,576
2/23			800		800	2,138,664
2/26						5,513,136
3/ 1			1,600		600	7,021,272
3/ 5						6,930,128
3/ 8						2,694,400
3/12						3,275,504
3/15						3,307,504
3/19			3,200		3,200	4,551,808
3/23					3,200	4,572,420
3/26						2,764,144
3/29						2,697,600
4/ 2			1,600		1,600	2,537,312
4/ 5					6,400	3,652,176
4/ 9						7,633,176
4/13						4,742,848
4/16						11,720,416
4/19						11,912,800
4/23		3,200			3,200	19,719,760
4/26			3,200		3,200	20,040,240
4/30						19,407,184

Table 1.—Organisms Per Cubic Meter in Plankton of Stockton Channel in 1913—(*Continued*)

1913	Closterium sp	Mougeotia sp	Staurastrum A	Straurastrum sp	Total Conjugatae	Total Algae
5/ 3						22,003,888
5/ 7						21,327,392
5/11						34,986,656
5/14						64,188,448
5/17						50,101,520
5/21						41,832,640
5/24						45,590,160
5/27						76,558,011
5/31					3,200	82,083,296
6/ 3						89,857,408
6/ 7		6,400		3,200	9,600	79,290,912
6/11						76 248,736
6/16			6,400		6 400	57,502,784
6/18						69,738,928
6/21				3,200	3,200	57,741,536
6/25		105,792			108,992	60,357,056
6/28			105,792		112,192	81,289,856
7/ 3						56,258,752
7/ 5			3,200		6,400	22,693,888
7/ 9			6,400		6,400	21,500,080
7/12		3,200			3,200	31,667,000
7/16		3,200	6,400		9,600	66,012,512
7/19						36,812,226
7/23		3,200			9,590	19,758,102
7/26				3,200	6,400	35 865,002
7/30						26,959,264
8/ 2						25,771,960
8/ 6					112,192	21,004,416
8/ 9		158,688		158,688	528,960	24,498,752
8/13		846,336		3,200	1,275,904	48,334,132
8/15		846,336	3,200		875,136	25,866,952
8/20		476,064			581,856	27,142,336
8/23		370,272			634,752	29,838 048
8/27		264,480	3,200		274,080	37,911,936
8/31		476,064			581,856	47,045,228
9/ 2		1,745,568			1,967,352	43,650,304
9/ 6		1,639,776	105,792		2,013,248	55,138,336
9/ 9		264,480	6,400		274,080	41,621,056
9/13		158,688			165,088	40,754,320
9/17		158,688	6,400		270,880	36,295,360
9/20					105,792	39,967,096
9/24			211,584	52,896	317,376	51,644,000
9/27		52,896	52,896		112,192	50,444,544
10/ 1			12,800		1,263,104	47,584,896
10/ 4			6,400		6,400	30,570,496
10/ 8		52,896	105,792	52,896	211,584	39,120,434
10/11		52,896	6,400		72,096	40,825,920
10/15		105,792	52,896		211,584	42,368 000
10/18		52,896	52,896	52,896	165,088	39,380,224
10/22			12,800		19,200	42,718,176
10/26			52,896		52,896	44,788,416
10/29			52,896		158,688	44,852,512
11/ 1						23,147,552
11/ 5			12,800		12,800	20,024,992
11/ 8						13,931,456
11/12			1,600		1,600	27,145,248
11/15						15,993,992
11/19		1,600	1,600		9,600	13,059,416
11/22		1,600			1,600	14,611,552
11/26		1,600			3,200	11,859,808

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Closterium sp	Mougeotia sp	Staurastrum A	Straurastrum sp	Total Conjugatae	Total Algae
11/30					1,600	12,232,528
12/ 3			6,400		8,000	13,796,160
12/ 6					3,200	9,832,912
12/10					21,336	4,144,964
12/14						4,602,940
12/17					1,200	4,230,268
12/20						4,599,528
12/24			400		400	2,282,716
12/27		400			400	5,153,036
12/31						4,127,276

1913	Total Chlorophyll bearing	Ceratium hirundinella	Cercomonas crassicauda	Cercomonas sp	Chlamydomonas sp	Chromulina sp
1/ 5	1,197,572					
1/ 8	456,016					
1/12	917,256					
1/15	4,255,716					945,516
1/19	7,257,952					958,740
1/22	3,024,248					99,180
1/26	1,059,168					251,256
1/29	2,079,556					271,092
2/ 2	1,513,724					13,224
2/ 5	2,157,088					152,076
2/ 8	2,259,656					462,840
2/12	1,950,704					251,256
2/15	3,675,424					317,376
2/19	5,542,136					1,481,088
2/23	2 528,560					277,704
2/26	6,268,080					687,648
3/ 1	7,113,336					423,168
3/ 5	7,019,072					
3/ 8	2,755,296					1,600
3/12	3,322,000					
3/15	3,488,592					79,344
3/19	4,599,504					
3/23	4,686,212					
3/26	3,117,568					158,688
3/29	3,179,968					423,168
4/ 2	2,697,600					79,344
4/ 5	3,666,576					1,600
4/ 9	7,647,576					
4/13	4,755,648					1,600
4/16	12,156,384					317,376
4/19	11,976,896					52,896
4/23	20,939,568					290,928
4/26	20,254,224					158,688
4/30	19,542,624					132,240
5/ 3	22,294,816					79,344
5/ 7	21,378,688					52,896
5/11	35,355,328					132,240
5/14	64,300,640					105,792
5/17	50,683,376					317,376
5/21	42,053,824					
5/24	45,854,640					
5/27	77,086,976				3,200	264,480
5/31	83,517,888					1,322,400
6/ 3	90,601,152					105,792

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Total Chlorophyll bearing	Ceratium hirundinella	Cercomonas crassicauda	Cercomonas sp	Chlamydomonas sp	Chromulina sp
6/ 7	80,295,936					105,792
6/11	77,356,352					211,584
6/16	58,996,672					899,232
6/18	71,136,624					634,752
6/21	58,441,984					370,272
6/25	61,801,248					581,856
6/28	83,154,016					740,544
7/ 3	59,196,832					1,428,192
7/ 5	24,657,440					634,752
7/ 9	24,516,656					2,486,112
7/12	37,862,232					4,919,328
7/16	71,364,608		3,200			5,183,808
7/19	43,853,794				105,792	6,929,376
7/23	23,044,054					3,173,760
7/26	44,063,882					7,299,648
7/30	31,213,344		3,200			3,279,552
8/ 2	30,601,496					3,967,200
8/ 6	25,992,640					3,226,656
8/ 9	27,411,232					1,481,088
8/13	56,819,882		3,200			6,347,520
8/15	32,637,640					4,231,680
8/20	37,612,544					6,876,480
8/23	38,727,776			3,200		6,770,688
8/27	46,325,600				423,168	5,289,600
8/31	58,364,972			264,480	370,272	5,554,080
9/ 2	58,853,856			1,533,984	687,648	7,722,816
9/ 6	71,957,264			370,272	105,792	10,579,200
9/ 9	64,266,944			423,168		11,531,328
9/13	62,388,784			211,584		13,224,000
9/17	57,307,872	3,200	3,200	158,688		17,825,952
9/20	49,541,272		52,896			5,977,248
9/24	59,108,736					6,559,104
9/27	55,149,632					9,785,760
10/ 1	59,909,664					9,151,008
10/ 4	37,200,696	6,400				5,342,496
10/ 8	45,580,140	6,400				4,813,536
10/11	47,708,800	6,400				4,549,056
10/15	46,335,128					2,539,008
10/18	45,833,536					5,395,392
10/22	48,536,736					4,813,536
10/26	49,760,640					4,231,680
10/29	52,006,272					6,612,000
11/ 1	31,041,856					7,299,648
11/ 5	25,526,176					5,448,288
11/ 8	20,151,680					5,977,248
11/12	40,772,368					12,906,624
11/15	23,200,648		52,896			6,347,520
11/19	18,674,392		1,600			5,104,464
11/22	20,426,064					5,210,256
11/26	14,403,616					2,089,392
11/30	15,549,728					2,856,384
12/ 3	16,574,800					2,221,632
12/ 6	11,905,456		1,600			1,957,152
12/10	5,169,854					806,664
12/14	5,796,300					859,560
12/17	5,633,212		132,240			932,292
12/20	5,321,200				400	621,528
12/24	3,422,780				400	932,292
12/27	6,502,284					971,964
12/31	5,146,724					641,364

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cryptomonas sp	Dinobryon sertularia	Eudorina elegans	Euglena deses	Euglena viridis	Flagellate unidentified
1/ 5						
1/ 8			400			
1/12			800			
1/15			400			
1/19			2,000			
1/22			800			
1/26			800			
1/29		400	2,400			
2/ 2			2,400			
2/ 5			1,600			19,836
2/ 8			8,000			
2/12			1,600			
2/15			1,600			
2/19		1,600	20,800		1,600	800
2/23			6,400		26,448	
2/26			9,600		1,600	1,600
3/ 1			9,600			
3/ 5			9,600			
3/ 8			3,200			
3/12			1,600		1,600	
3/15			16,000			
3/19			3,200		1,600	
3/23			3,200			52,896
3/26			9,600			
3/29			57,600			
4/ 2			79,344			
4/ 5			9,600			
4/ 9			6,400			
4/13			9,600			
4/16			9,600			
4/19			3,200			
4/23			1,600			
4/26			3,200			
4/30					1,600	
5/ 3						
5/ 7						
5/11					105,792	
5/14					3,200	
5/17					105,792	
5/21			3,200			
5/24						
5/27						
5/31			6,400			
6/ 3			6,400			
6/ 7						
6/11						
6/16			6,400			
6/18			19,200			
6/21			6,400			
6/25			12,800		158,688	3,200
6/28			12,800			
7/ 3			32,000			
7/ 5					3,200	
7/ 9			19,200		211,584	
7/12			6,400		793,440	
7/16			6,400		158,688	
7/19					6,400	
7/23					105,792	
7/26					370,272	
7/30			6,400		423,168	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cryptomonas sp	Dinobryon sertularia	Eudorina elegans	Euglena deses	Euglena viridis	Flagellate unidentified
8/ 2					105,792	
8/ 6				6,400	476,064	
8/ 9					264,480	
8/13					3,200	
8/15						
8/20					158,688	
8/23					158,688	
8/27						105,792
8/31					105,792	
9/ 2					158,688	
9/ 6					264,480	
9/ 9					105,792	
9/13						
9/17						
9/20	317,376				158,688	
9/24			6,400			
9/27	476,064				211,584	
10/ 1	158,688		6,400		158,688	
10/ 4	105,792		105,792		52,896	
10/ 8			19,200		105,792	
10/11			3,200		105,792	
10/15				52,896		
10/18						
10/22	211,584					
10/26						
10/29	52 896			6,400		
11/ 1					6,400	
11/ 5						
11/ 8					6,400	
11/12	264,480			3,400	79,344	
11/15	105,792			6,400	6,400	
11/19	79,344		3,200		79,344	
11/22	185,136		3,200		12,800	
11/26	185,136		1,600			
11/30	132,240	3,200	3,200			
12/ 3	52,896		1,600			
12/ 6	1,600		3,200		3,200	
12/10	66,120		13 224			
12/14	400	400				
12/17	99 180		800			
12/20	26,448					
12/24	59,508		800		800	
12/27	66,120		800			
12/31	112,404		400			

1913	Hemidinium nasutum	Mallomonas sp	Pandorina morum	Peridinium cinctum	Peridinium sp	Phacus pleuronectes
1/ 5						
1/ 8						
1/12						
1/15			13,224			
1/19			800			
1/22						
1/26						
1/29			800			
2/ 2			13,224			
2/ 5						
2/ 8			26,448			

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Hemidinium nasutum	Mallomonas sp	Pandorina morum	Peridinium cinctum	Peridinium sp	Phacus pleuronectes
2/12						
2/15			1,600	800		
2/19			16,000			
2/23						
2/26						
3/ 1			6,400			
3/ 5						
3/ 8						
3/12			3,200			
3/15			6,400			
3/19						
3/23			3,200			
3/26			79,344			
3/29						
4/ 2						
4/ 5			1,600			
4/ 9			6,400			
4/13			1,600			
4/16			3,200			
4/19			1,600			
4/23			1,600			
4/26			3,200			
4/30						
5/ 3						
5/ 7						
5/11		52,896		105,792		
5/14						
5/17						
5/21			6,400			
5/24						
5/27						
5/31						
6/ 3					158,688	
6/ 7					211,584	
6/11						
6/16			3,200		158,688	
6/18			3,200	317,376	3,200	
6/21						
6/25						
6/28				105,792		
7/ 3				423,168		
7/ 5		3,200		1,005,024		
7/ 9				3,200		
7/12						
7/16						
7/19						
7/23						
7/26				317,376		
7/30	52,896			3,200		
8/ 2	634,752					
8/ 6	1,163,712					
8/ 9	952,128					
8/13				105,792		
8/15	1,745,568		3,200			
8/20	2,168,736					
8/23	1,533,984					
8/27	2,380,320			3,200		
8/31	4,125,888			158,688		
9/ 2	4,178,784	3,200		370,272		
9/ 6	4,866,432			3,200		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Hemidinium nasutum	Mallomonas sp	Pandorina morum	Peridinium cinctum	Peridinium sp	Phacus pleuronectes
9/ 9	9,679,968			105,792		
9/13	7,617,024			105,792		
9/17	2,221,632			3,200		
9/20	2,433,216					
9/24	528,960			52,896		
9/27	3,861,408			52,896		
10/ 1	2,168,736			52,896		264,480
10/ 4	528,960			52,896		158,688
10/ 8	317,376					158,688
10/11	1,481,088			52,896		105,792
10/15	264,480			52,896		52,896
10/18	211,584					
10/22						
10/26						
10/29	52,896					52 896
11/ 1				52,896		476,064
11/ 5				52,896		
11/ 8						211,584
11/12			52,896			52,896
11/15						370,272
11/19				1,600		238,032
11/22	1,600					238,032
11/26				1,600		52,896
11/30			3,200			52,896
12/ 3			1,600			52,896
12/ 6						
12/10			19,836			26,448
12/14			2,400			26,448
12/17						13,224
12/20						19,836
12/24			400			400
12/27						13,224
12/31						400

1913	Platydorina caudata	Pleodorina californica	Pteromonas sp	Spondylomorum quarternarium	Synura uvella	Trachelomonas euchlora
1/ 5						
1/ 8						
1/12						
1/15						
1/19						
1/22						
1/26						800
1/29						
2/ 2						
2/ 5						
2/ 8						
2/12						
2/15						
2/19						39,672
2/23						39,672
2/26						52,896
3/ 1						
3/ 5						
3/ 8					3,200	
3/12						1,600
3/15						
3/19						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Platydorina caudata	Pleodorina californica	Pteromonas sp	Spondylomorum quarternarium	Synura uvella	Trachelomonas euchlora
3/23						52,896
3/26						52,896
3/29						1,600
4/ 2						1,600
4/ 5						1,600
4/ 9						
4/13						
4/16						105,792
4/19				3,200		1,600
4/23						476,064
4/26						52,896
4/30						1,600
5/ 3						105,792
5/ 7						
5/11						
5/14						3,200
5/17						
5/21						
5/24						158,688
5/27						
5/31						
6/ 3						158,688
6/ 7						
6/11						
6/16						3,200
6/18						158,688
6/21			158,688			3,200
6/25						3,200
6/28						
7/ 3						
7/ 5			158,688			
7/ 9			32,000			
7/12						
7/16						
7/19						
7/23						
7/26			105,792			
7/30						
8/ 2	6,400	6,400			3,200	3,200
8/ 6					6,400	3,200
8/ 9			3,200			
8/13	6,400	6,400	105,792		3,200	
8/15					3,200	
8/20			158,688			
8/23			3,200		264,480	
8/27						
8/31						
9/ 2	12,800				6,400	
9/ 6						
9/ 9	6,400				105,792	
9/13						
9/17					3,200	
9/20			211,584		158,688	
9/24						
9/27						
10/ 1						
10/ 4	6,400					
10/ 8			52,896		52,896	
10/11					52,896	
10/15						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Platydorina caudata	Pleodorina californica	Pteromonas sp	Spondylomorum quarternarium	Synura uvella	Trachelomonas euchlora
10/18						
10/22						
10/26						
10/29	6,400					
11/ 1						
11/ 5						
11/ 8						
11/12						
11/15						
11/19					3,200	
11/22						
11/26						
11/30						1,600
12/ 3						
12/ 6						
12/10						
12/14						
12/17						400
12/20					400	
12/24				13,224		
12/27						
12/31						400

1913	Trachelomonas sp	Trachelomonas volvocina	Total Mastigophora	Amoeba proteus	Amoeba radiosa	Arcella vulgaris
1/ 5						
1/ 8			400			
1/12			800	800		
1/15		19,836	978,976			
1/19		39,672	1,001,212	400		
1/22	400	400	100,780			
1/26		19,836	272,692			
1/29		19,836	294,528			
2/ 2		400	29,248			
2/ 5			173,512			800
2/ 8	800	39,672	537,760			
2/12		800	253,656			
2/15		800	322,176			
2/19			1,561,560			1,600
2/23		39,672	389,896			
2/26		1,600	754,944			
3/ 1		52,896	493,664			
3/ 5		79,344	88,944			
3/ 8		52,896	60,896			
3/12		52,896	60,896			
3/15		79,344	181,088			
3/19		52,896	57,696			
3/23		1,600	113,792			
3/26		52,896	353,424	1,600		
3/29			482,368			
4/ 2			160,288			
4/ 5			14,400			
4/ 9		1,600	14,400			
4/13			12,800			3,200
4/16			435,968			
4/19		1,600	64,096			
4/23		370,272	1,219,808	3,200		
4/26			217,984			

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Trachelomonas sp	Trachelomonas volvocina	Total Mastigophora	Amoeba proteus	Amoeba radiosa	Arcella vulgaris
4/30			135,440		1,600	
5/ 3		105,792	290,928	1,600	79,344	
5/ 7			52,896		1,600	
5/11		79,344	370,272		1,600	
5/14	3,200		112,192			
5/17		264,480	581,856			
5/21		211,584	221,184		3,200	
5/24		105,792	264,480			
5/27		264,480	532,160			
5/31		211,584	1,540,384			
6/ 3		317,376	746,944			
6/ 7		687,648	1,005,024			
6/11		793,440	1,110,816		3,200	
6/16		423,168	1,497,088			
6/18		264,480	1,503,488			
6/21		158,688	700,448			
6/25		687,648	1,447,392			
6/28		1,005,024	1,867,360			
7/ 3		1,057,920	2,941,280			
7/ 5		264,480	2,069,344	6,400		
7/ 9		264,480	3,016,576			
7/12		476,064	6,195,232			3,200
7/16			5,352,096			
7/19			7,041,568			
7/23		3,200	3,285,952			
7/26		105,792	8,198,880			
7/30			4,244,480			
8/ 2		105,792	4,832,736			
8/ 6		105,792	4,988,224			
8/ 9		211,584	2,912,480			
8/13		1,057,920	8,485,750	158,688		
8/15		793,440	6,780,288	105,792		
8/20		1,110,816	10,473,408			
8/23		158,688	8,892,928			
8/27		317,376	8,519,456			
8/31		740,544	11,319,744			
9/ 2		528,960	15,203,552			
9/ 6		634,752	16,824,128		3,200	6,400
9/ 9		687,648	22,645,888			
9/13		476,064	21,634,464			
9/17		793,440	21,012,512		158,688	
9/20		264,480	9,574,176		211,584	
9/24		317,376	7,464,736			
9/27		317,376	14,705,088			
10/ 1		423,168	12,377,664		52,896	
10/ 4		370,272	6,630,200			
10/ 8		952,128	6,459,712			
10/11		581,856	6,935,776		52,896	
10/15		1,057,920	4,020,024			
10/18		846,336	6,453,312			
10/22		793,440	5,818,560		211,584	
10/26		740,544	5,025,120		476,064	
10/29		476,064	7,259,552	6,400	370,272	
11/ 1		211,584	8,052,992		264,480	
11/ 5			5,606,976			6,400
11/ 8		158,688	6,373,120			
11/12		502,512	13,865,152			
11/15		476,064	7,365,344			
11/19		158,688	5,667,872			
11/22		158,688	5,814,512	3,200		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Trachelomonas sp	Trachelomonas volvocina	Total Mastigophora	Amoeba proteus	Amoeba radiosa	Arcella vulgaris
11/26		211,584	2,543,808			
11/30		264,480	3,317,200			
12/ 3		449,616	2,780,240			3,200
12/ 6		105,792	2,072,544			
12/10		112,404	1,024,860			
12/14		330,600	1,219,808		400	
12/17		370,272	1,429,392	400		
12/20		59,508	748,120	400		
12/24		132,240	1,140,464	400	400	
12/27		297,540	1,349,648			
12/31		284,316	1,039,284			

1913	Difflugia corona	Difflugia pyriformis	Hyalodiscus sp	Hyalosphenia cuneata	Hyalosphenia papilio	Microgromia socialis
1/ 5		13,224				
1/ 8						
1/12						
1/15						
1/19						
1/22		400				
1/26						
1/29						
2/ 2						
2/ 5						
2/ 8						
2/12						
2/15		1,600				
2/19		3,200				4,800
2/23						800
2/26		52,896				
3/ 1					3,200	1,600
3/ 5						
3/ 8						
3/12						
3/15						
3/19						
3/23		1,600				
3/26		1,600				
3/29						1,600
4/ 2		52,896				
4/ 5		52,896				1,600
4/ 9		79,344				
4/13						1,600
4/16						1,600
4/19						
4/23		1,600				79,344
4/26						185,136
4/30		105,792				
5/ 3		1,600				
5/ 7						1,600
5/11		158,688				1,600
5/14		211,584				
5/17	6,400	423,168				
5/21		211,584				
5/24		317,376				
5/27		952,128		3,200		
5/31		370,272		105,792		105,792
6/ 3		1,322,400				

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Difflugia corona	Difflugia pyriformis	Hyalodiscus sp	Hyalosphenia cuneata	Hyalosphenia papilio	Microgromia socialis
6/ 7		740,544			3,200	3,200
6/11		158,688				3,200
6/16		423,168				
6/18		158,688				3,200
6/21		19,200				3,200
6/25		581,856				
6/28		581,856				
7/ 3		105,792				
7/ 5		211,584				
7/ 9		264,480				
7/12						
7/16						3,200
7/19		3,200				
7/23						105,792
7/26		264,480				
7/30						3,200
8/ 2						
8/ 6						
8/ 9		3,200				
8/13						
8/15						105,792
8/20		3,200				
8/23	6,400	3,200				
8/27						3,200
8/31						
9/ 2						
9/ 6						
9/ 9		6,400	3,200			
9/13			3,200			
9/17						105,792
9/20			158,688			52,896
9/24			105,792			52,896
9/27			52,896			
10/ 1						211,584
10/ 4						264,480
10/ 8						211,584
10/11						264,480
10/15		105,792				52,896
10/18						
10/22			634,752			211,584
10/26			370,272			
10/29			52,896			211,584
11/ 1						52,896
11/ 5						105,792
11/ 8						
11/12	3,200		132,240			
11/15			158,688			
11/19		3,200	1,600			1,600
11/22						
11/26						
11/30						
12/ 3						
12/ 6			1,600			
12/10		800				
12/14						
12/17						
12/20						
12/24		400				
12/27		400				
12/31						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Nebela sp	Trinema sp	Total Rhizopoda	Actinophrys sol	Heterophrys fockei	Heterophrys sp
1/ 5			13,224			
1/ 8						
1/12			800			
1/15						
1/19			400			
1/22			400			
1/26						
1/29						
2/ 2						
2/ 5			800			
2/ 8						
2/12						
2/15			1,600			
2/19			9,600			
2/23			800			
2/26						
3/ 1			4,800			
3/ 5						
3/ 8						
3/12						
3/15			1,600			1,600
3/19			1,600			
3/23			1,600			
3/26			3,200			
3/29			4,800			
4/ 2			52,896			
4/ 5			54,496			
4/ 9			80,944			
4/13			67,696			
4/16			3,200			
4/19						
4/23			163,488			
4/26			238,032			
4/30			107,392			
5/ 3			82,844			
5/ 7			3,200			
5/11			161,888			
5/14			211,584			
5/17			429,568			
5/21			214,784			
5/24			317,376			
5/27			955,328			
5/31			781,856			
6/ 3			1,533,984			
6/ 7			746,944			
6/11			165,088			
6/16			423,168			
6/18			161,888			
6/21			22,400			
6/25			581,856			
6/28			581,856			
7/ 3			105,792			
7/ 5			224,384			
7/ 9	6,400		270,880			
7/12			3,200			
7/16	105,792		112,192			
7/19	3,200		6,400			
7/23			105,792			
7/26	3,200		267,680			
7/30			3,200		44,800	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Nebela sp	Trinema sp	Total Rhizopoda	Actinophrys sol	Heterophrys fockei	Heterophrys sp
8/ 2					528,960	
8/ 6					105,792	
8/ 9	105,792		108,992		317,376	
8/13	105,792		846,326		105,792	
8/15			317,376		211,584	211,584
8/20		158,688	161,888			
8/23			168,288		3,200	
8/27			112,192		3,200	
8/31			264,480			
9/ 2			3,200			
9/ 6			9,600			
9/ 9		105,792	115,392			
9/13			3,200			
9/17		3,200	267,680			
9/20			323,168		211,584	
9/24			158,688		211,584	
9/27		105,792	158,688			
10/ 1			264,480		158,688	
10/ 4			264,480		264,480	
10/ 8			211,584		158,688	
10/11			370,272		6,400	
10/15		105,792	370,272		52,896	
10/18					52,896	
10/22			1,163,712	105,792	105,792	
10/26			581,856	581,856		
10/29			858,524	52,896		
11/ 1		211,584	381,856			
11/ 5		211,584	323,776			
11/ 8						
11/12		1,600	137,040			
11/15			158,688			
11/19			6,400			
11/22			3,200			
11/26						
11/30				1,600		
12/ 3			3,200			
12/ 6			1,600			
12/10			800			
12/14			400			
12/17			400			
12/20			400			
12/24			1,200			
12/27			400			
12/31						

1913	Nuclearia simplex	Pinaciophora fluviatilis	Raphidiophrys elegans	Total Heliozoa	Askenasia elegans	Bursaria sp
1/ 5						
1/ 8						
1/12						400
1/15						
1/19						
1/22						
1/26						
1/29					400	
2/ 2						
2/ 5					800	
2/ 8					1,600	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Nuclearia simplex	Pinaciophora fluviatilis	Raphidiophrys elegans	Total Heliozoa	Askenasia elegans	Bursaria sp
2/12						
2/15						
2/19						
2/23						
2/26						
3/ 1						
3/ 5						
3/ 8						
3/12					1,600	
3/15				1,600		
3/19	1,600					1,600
3/23						
3/26						
3/29	3,200					
4/ 2						
4/ 5						
4/ 9	1,600					
4/13	52,896					
4/16	1,600					
4/19						
4/23	79,344					
4/26	52,896		52,896	52,896		
4/30			132,240	132,240		3,200
5/ 3						
5/ 7			211,584	211,584		
5/11			158,688	158,688		
5/14			3,200	3,200		
5/17						
5/21			1,216,608	1,216,608		
5/24						
5/27						
5/31			3,200	3,200		
6/ 3						
6/ 7			740,544	740,544		
6/11			1,005,024	1,005,024		
6/16			1,322,400	1,322,400		
6/18			158,688	158,688		
6/21			264,480	264,480		
6/25			1,851,360	1,851,360		
6/28			740,544	740,544		
7/ 3			793,440	793,440		
7/ 5	6,400		528,960	528,960		
7/ 9			846,336	846,336		
7/12			158,688	158,688		
7/16	3,200		528,960	528,960		
7/19			370,272	370,272		
7/23			317,376	317,376		
7/26			370,272	370,272		
7/30			370,272	415,072		
8/ 2			1,269,504	1,798,464		
8/ 6			264,480	370,272		
8/ 9			423,168	740,544		
8/13	158,688		1,745,568	1,851,360		
8/15			528,960	952,128		
8/20			317,376	317,376		
8/23			1,586,880	1,590,080		
8/27	3,200		105,792	108,992		
8/31			687,648	687,648		
9/ 2	3,200		211,584	211,584		
9/ 6						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Nuclearia simplex	Pinaciophora fluviatilis	Raphidiophrys elegans	Total Heliozoa	Askenasia elegans	Bursaria sp
9/ 9						
9/13			3,200	3,200		
9/17						
9/20				211,584		
9/24				211,584		
9/27				211,584		105,792
10/ 1				52,896		
10/ 4				264,480		
10/ 8				158,688		
10/11	52,896	423,168		429,568		
10/15	105,792	52,896		105,792		
10/18		476,064		528,960		
10/22	105,792	370,272		581,856		
10/26	105,792	317,376	211,584	1,110,816		
10/29		370,272		423,168		
11/ 1		476,064		476,064		
11/ 5		105,792	4,549,056	4,654,848		
11/ 8			1,428,192	1,428,192		
11/12		79,344	3,702,720	3,782,064		
11/15		52,896	1,745,568	1,798,464		
11/19			819,888	819,888		
11/22			1,600	1,600		
11/26		52,896	1,600	54,496		
11/30			396,720	398 320		
12/ 3			1,600	1,600		
12/ 6			52,896	52,896		
12/10						
12/14						
12/17						
12/20						
12/24						
12/27			400	400		
12/31						

1913	Chilodon sp	Ciliate unidentified	Coleps hirtus	Colpoda sp	Cyclidium sp	Didinium nasutum
1/ 5						
1/ 8						
1/12						
1/15						400
1/19						
1/22		26,448		400		
1/26		46,284				52,896
1/29		52,896				400
2/ 2		800				
2/ 5		33,060				
2/ 8		3,200				4,800
2/12		52,896				1,600
2/15		66,120				39,672
2/19		1,600				
2/23		26,448	800			3,200
2/26		105,792				1,600
3/ 1		1,600				3,200
3/ 5		52,896				
3/ 8		79,344				
3/12						
3/15						
3/19	1,600	52,896				

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Chilodon sp	Ciliate unidentified	Coleps hirtus	Colpoda sp	Cyclidium sp	Didinium nasutum
3/23		132,240				
3/26						1,600
3/29		3,200				
4/ 2		6,400				
4/ 5						
4/ 9		1,600				
4/13						3,200
4/16		1,600				
4/19				1,600		
4/23						
4/26		1,600				1,600
4/30	3,200					
5/ 3						
5/ 7						
5/11						
5/14						
5/17						
5/21						
5/24						
5/27						
5/31						
6/ 3						
6/ 7						
6/11						
6/16						
6/18						
6/21						
6/25						
6/28						
7/ 3				3,200		
7/ 5				3,200		
7/ 9						
7/12						
7/16						
7/19						
7/23						
7/26						
7/30						
8/ 2	3,200					
8/ 6						
8/ 9						
8/13					158,688	
8/15					105,792	
8/20					105,792	
8/23					264,480	
8/27				6,400	158,688	
8/31					158,688	
9/ 2					317,376	
9/ 6					476,064	
9/ 9						
9/13					264,480	
9/17					3,200	
9/20						
9/24					264,480	
9/27			52,896		105,792	
10/ 1					105,792	
10/ 4					158,688	
10/ 8					52,896	
10/11					211,584	
10/15						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Chilodon sp	Ciliate unidentified	Coleps hirtus	Colpoda sp	Cyclidium sp	Didinium nasutum
10/18					158,688	
10/22						
10/26						
10/29			264,480			
11/ 1			105,792			
11/ 5						
11/ 8						
11/12			1,600			32,000
11/15						19,200
11/19						1,600
11/22						
11/26						
11/30						
12/ 3						
12/ 6	22,400					3,200
12/10						
12/14			132,240			
12/17			119,016			
12/20			66,120			
12/24			19,836			
12/27			400			
12/31						

1913	Enchelys sp	Euplotes harpa	Euplotes patella	Frontonia sp	Halteria grandinella	Hastatella radians
1/ 5						
1/ 8						
1/12						
1/15		1,600				
1/19		13,224				
1/22		11,200				
1/26		19,836			52,896	
1/29		33,060			46,284	
2/ 2		13,224			800	
2/ 5		26,448			800	1,600
2/ 8		16,000	800		4,800	
2/12		39,672			1,600	
2/15		158,688	52,896		4,800	52,896
2/19		145,464	52,896		1,600	1,600
2/23	1,600	132,240	66,120		3,200	1,600
2/26		132,240	105,792		3,200	3,200
3/ 1		317,376	52,896		105,792	12,800
3/ 5		6,400			52,896	
3/ 8		158,688	3,200		3,200	
3/12		79,344	1,600	158,688		
3/15		158,688	12,800		3,200	
3/19		370,272				
3/23		264,480	9,600		9,600	
3/26		79,344				
3/29		35,200				
4/ 2		70,400	3,200			
4/ 5		211,584	9,600		105,792	
4/ 9		132,240				6,400
4/13		25,600				9,600
4/16						9,600
4/19		6,400				105,792
4/23						1,600
4/26		1,600				

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Enchelys sp	Euplotes harpa	Euplotes patella	Frontonia sp	Halteria grandinella	Hastatella radians
4/30						
5/ 3						
5/ 7						
5/11				3,200		
5/14						
5/17						
5/21						
5/24						
5/27						
5/31						
6/ 3						
6/ 7						
6/11						
6/16						
6/18						
6/21						
6/25						
6/28						
7/ 3						
7/ 5						
7/ 9						
7/12						
7/16						
7/19						
7/23						
7/26						
7/30						
8/ 2						
8/ 6						
8/ 9						
8/13						
8/15		12,800				
8/20						
8/23						
8/27						
8/31						
9/ 2						
9/ 6						
9/ 9						
9/13						
9/17						
9/20						
9/24						
9/27						
10/ 1						
10/ 4						
10/ 8						
10/11						
10/15						
10/18						
10/22						
10/26						
10/29		6,400			52,896	
11/ 1	52,896	44,800				
11/ 5		19,200			52,896	
11/ 8		89,600				
11/12		528,960				
11/15		264,480				
11/19		211,584				
11/22	1,600	19,200				

Table 1.—Organisms Per Cubic Meter in Plankton of Stockton Channel in 1913—(*Continued*)

1913	Enchelys sp	Euplotes harpa	Euplotes patella	Frontonia sp	Halteria grandinella	Hastatella radians
11/26		28,800				
11/30		52,896				
12/ 3		9,600				
12/ 6		12,800				
12/10						
12/14	33,060	800				13,224
12/17					400	
12/20						
12/24					800	400
12/27						13,224
12/31					13,224	

1913	Holophrya sp	Loxophyllum sp	Paramecium aurelia	Paramecium bursaria	Paramecium caudatum	Pleuronema sp
1/ 5						
1/ 8						
1/12				400		
1/15			1,200	400		
1/19			26,448	800		
1/22			26,448		400	
1/26			79,344	400		
1/29			72,732			
2/ 2			4,800			
2/ 5			400			
2/ 8			3,200			
2/12	39,672		26,448			
2/15			119,016			
2/19			3,200			
2/23			1,600			
2/26	3,200					
3/ 1						
3/ 5	1,600					
3/ 8	52,896					
3/12	581,856		1,600			
3/15	9,600			9,600		
3/19	238,032	3,200		6,400		
3/23	105,792		3,200	3,200		
3/26	132,240					
3/29	158,688					
4/ 2	290,928					
4/ 5				1,600		
4/ 9	211,584			3,200		
4/13	3,200					
4/16	185,136					
4/19	79,344					
4/23	211,584					
4/26	105,792			3,200		
4/30	211,584					
5/ 3	105,792		3,200			
5/ 7	132,240					
5/11	79,344					
5/14	105,792					
5/17	1,005,024		6,400			
5/21	105,792					
5/24	264,480					
5/27						
5/31						
6/ 3						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Holophrya sp	Loxophyllum sp	Paramecium aurelia	Paramecium bursaria	Paramecium caudatum	Pleuronema sp
6/ 7						
6/11	158,688					
6/16	3,200					
6/18	3,200					
6/21	3,200					
6/25	3,200					
6/28	158,688					
7/ 3	3,200					3,200
7/ 5	158,688					
7/ 9	211,584					
7/12	3,200					
7/16	6,400					
7/19						
7/23						
7/26	211,584					
7/30	105,792					
8/ 2	105,792					
8/ 6	105,792					
8/ 9	740,544					
8/13	634,752					
8/15	317,376					
8/20	105,792					
8/23	158,688					
8/27	105,792					
8/31	3,200					
9/ 2	3,200					
9/ 6	317,376					
9/ 9	211,584					
9/13						
9/17	3,200					
9/20	370,272					
9/24	158,688					
9/27	211,584					
10/ 1	211,584					
10/ 4	52,896					
10/ 8	423,168		6,400			
10/11	105,792					
10/15	105,792					
10/18	105,792					
10/22	370,272					
10/26	52,896					
10/29						
11/ 1	52,896		51,200	264,480		
11/ 5	52,896		70,400			
11/ 8	52,896		96,000	57,600		6,400
11/12	52,896			581,856		132,240
11/15			25,600			6,400
11/19	105,792		79,344	1,600		79,344
11/22	79,344		6,400			79,344
11/26			3,200			105,792
11/30	238,032		3,200			
12/ 3	79,344		19,200	6,400		79,344
12/ 6	1,600			6,400		3,200
12/10			13,224	13,224	4,000	26,448
12/14		800	10,400	800		39,672
12/17	13,224		145,464		9,600	
12/20	72,732		105,792	19,836	13,224	400
12/24	13,224		16,000	3,200	4,800	
12/27	59,508		72,732	13,224	5,600	
12/31	39,672		33,060	19,836		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Prorodon sp	Stentor coeruleus	Stentor niger	Tintinnidium fluviatile	Trachelius ovum	Trichodina pediculus
1/ 5		800	6,612			
1/ 8		400	1,200			
1/12		1,200	2,000			
1/15		33,060	26,448			
1/19		52,896	39,672			
1/22		72,732	112,404		800	
1/26		132,240	515,736			
1/29		26,448	158,688		400	
2/ 2			33,060			
2/ 5		400	39,672			
2/ 8			11,200			
2/12	52,896	1,600	66,120			
2/15	105,792	8,000	39,672			
2/19	800	800	52,896		1,600	3,200
2/23	66,120	1,600	105,792			1,600
2/26	3,200		67,200			6,400
3/ 1	105,792	12,800	158,688			9,600
3/ 5			185,136			
3/ 8	3,200		158,688			1,600
3/12		105,792	608,304			
3/15	16,000		35,200			
3/19	6,400		211,584			3,200
3/23	3,200	6,400	238,032			
3/26			132,240			
3/29	1,600		79,344			3,200
4/ 2		6,400	22,400			
4/ 5	6,400	6,400	28,800			
4/ 9		9,600				
4/13	6,400		6,400			
4/16			105,792		3,200	
4/19			41,600			
4/23		6,400	54,400			
4/26		3,200	211,584			
4/30	3,200		19,200			
5/ 3		6,400	105,792			
5/ 7			25,600			
5/11			105,792			
5/14						
5/17			211,584			
5/21						
5/24			6,400			
5/27						
5/31						
6/ 3						
6/ 7						
6/11						
6/16						
6/18						
6/21						
6/25						
6/28						
7/ 3						
7/ 5						
7/ 9						
7/12						
7/16						
7/19						
7/23						
7/26						6,400
7/30				105,792		

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Prorodon sp	Stentor coeruleus	Stentor niger	Tintinnidium fluviatile	Trachelius ovum	Trichodina pediculus
8/ 2						
8/ 6				3,200		
8/ 9						
8/13				6,400		
8/15				317,376		
8/20	3,200			3,200		
8/23				12,800		
8/27				3,200		
8/31				12,800		
9/ 2				6,400		
9/ 6						
9/ 9				264,480		
9/13				25,600		
9/17				211,584		
9/20						
9/24				6,400		
9/27				158,688		
10/ 1				211,584		
10/ 4				12,800		
10/ 8				6,400		
10/11				158,688		
10/15	52,896	6,400				
10/18				6,400		
10/22	52,896			105,792		
10/26						
10/29	6,400			158,688		
11/ 1			6,400			
11/ 5	6,400					
11/ 8	12,800					
11/12			9,600			16,000
11/15						
11/19	52,896		6,400			9,600
11/22	6,400		3,200			3,200
11/26	12,800	6,400				
11/30	3,200		22,400			
12/ 3	132,240	19,200	19,200			
12/ 6	9,600	3,200	16,000	3,200		
12/10		2,400	800	800		
12/14		800	39,672			800
12/17	1,600	32,672	79,344			
12/20	33,060	165,300	158,688			
12/24		2,400	7,200			800
12/27		46,284	400			
12/31		66,120	39,672			

1913	Vorticella longifilum	Vorticella sp	Total Ciliata	Acineta sp	Podophrya sp	Sphaerophrya sp
1/ 5			7,412			
1/ 8			1,600			
1/12			4,000			
1/15			63,108			
1/19			132,040			
1/22			250,832			
1/26			899,632			
1/29			391,308			
2/ 2			53,484			
2/ 5			103,180			
2/ 8			85,272			
2/12			284,104			

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Vorticella longifilum	Vorticella sp	Total Ciliata	Acineta sp	Podophrya sp	Sphaerophrya sp
2/15	1,600		649,152			
2/19			272,856			
2/23			411,920			
2/26			484,720			
3/ 1			780,544			
3/ 5	3,200		302,128			
3/ 8			460,816			
3/12			1,538,782			
3/15	3,200		248,288			
3/19			893,584			
3/23		3,200	778,944			
3/26			345,424			
3/29			281,232			
4/ 2			399,728			
4/ 5			370,176			
4/ 9			364,624			
4/13		1,600	70,408			
4/16	79,344	1,600	387,272			
4/19	105,792		340,528			
4/23	1,600	1,600	278,784			
4/26		79,344	411,120			
4/30		528,960	766,144			
5/ 3	1,600	687,648	910,432			
5/ 7		396,720	554,560			
5/11	1,600	396,720	586,656			
5/14		1,533,984	1,639,776			
5/17		1,692,672	2,915,680			
5/21	3,200	740,544	849,536			
5/24		1,428,192	1,699,072			
5/27	6,400	1,163,712	1,170,112			
5/31		1,322,400	1,322,400			
6/ 3		1,428,192	1,428,192			
6/ 7		2,433,216	2,433,216			
6/11		1,745,568	1,904,256			
6/16		1,798,464	1,801,604			
6/18		2,591,904	2,595,104			
6/21		3,596,928	3,600,128			
6/25	12,800	1,851,360	1,873,360			
6/28		2,062,944	2,221,632			
7/ 3		1,692,672	1,702,272			
7/ 5		2,644,800	2,806,688			
7/ 9		476,064	687,648			
7/12		740,544	743,744			
7/16		1,110,816	1,116,216			
7/19		1,057,920	1,057,920			
7/23		476,064	476,064			
7/26		1,269,504	1,487,488			
7/30	6,400	899,232	1,117,216			
8/ 2		1,639,776	1,748,768			
8/ 6		634,752	743,744			
8/ 9		687,648	1,428,192			
8/13		2,168,736	2,968,576			
8/15		1,375,296	2,128,640			
8/20		1,586,880	1,804,864			
8/23		793,440	1,229,408			
8/27		740,544	1,014,624			
8/31		1,851,360	2,028,048			
9/ 2		899,232	1,216,208			
9/ 6		899,232	1,692,672	3,200		
9/ 9		634,752	1,110,816			

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Vorticella longifilum	Vorticella sp	Total Ciliata	Acineta sp	Podophrya sp	Sphaerophrya sp
9/13		952,128	1,242,208			
9/17		1,005,024	1,222,008			
9/20		423,168	793,440			
9/24	52,896	581,856	1,064,320			
9/27	52,896	317,376	793,440			
10/ 1		1,322,400	1,851,360			
10/ 4		687,648	912,032			
10/ 8	6,400	528,960	1,024,224			
10/11		528,960	1,005,024			
10/15		687,648	852,736		6,400	
10/18		423,168	694,048			
10/22	52,896	1,692,672	2,274,528			
10/26	211,584	634,752	899,242			
10/29	105,792	1,481,088	2,095,744			
11/ 1		317,376	895,840			
11/ 5		158,688	360,480			
11/ 8			318,296			
11/12		290,928	1,646,080			
11/15			315,680	6,400		
11/19	79,344	211,584	839,088			52,896
11/22	9,600	211,584	419,872			
11/26	6,400	79,344	242,736			
11/30	158,688	79,344	559,360			
12/ 3	52,896	52,896	470,320			3,200
12/ 6	22,400	105,792	209,792		3,200	
12/10	39,672	13,224	113,792	800	800	800
12/14	125,628	72,732	470,618			
12/17	13,224	26,448	447,992		800	
12/20	46,284	39,672	721,108			
12/24	52,896	19,836	141,392		800	
12/27	52,896	33,060	297,328			
12/31	85,956	52,896	350,436			

1913	Total Suctoria	Total Protozoa without Mastigophora	Total Protozoa with Mastigophora	Collotheca egg, attached	Collotheca pelagica	Total Rhizota
1/ 5		20,636	20,636			
1/ 8		1,600	2,000			
1/12		4,800	5,600			
1/15		63,108	1,042,084			
1/19		132,440	1,133,652			
1/22		251,232	352,012			
1/26		899,632	1,172,324			
1/29		391,308	685,836			
2/ 2		53,484	82,732			
2/ 5		103,980	277,492			
2/ 8		85,272	623,032			
2/12		284,104	537,760			
2/15		650,752	972,928			
2/19		282,456	1,844,016			
2/23		412,720	802,616			
2/26		484,720	1,239,664			
3/ 1		785,344	1,279,008			
3/ 5		302,128	391,072			
3/ 8		460,816	521,712			
3/12		1,538,782	1,599,678			
3/15		251,488	432,576			
3/19		895,184	952,880			
3/23		780,544	894,336			

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Total Suctoria	Total Protozoa without Mastigophora	Total Protozoa with Mastigophora	Collotheca egg, attached	Collotheca pelagica	Total Rhizota
3/26		384,624	702,048			
3/29		286,032	768,400			
4/ 2		452,624	612,912			
4/ 5		424,672	439,072			
4/ 9		445,568	459,968			
4/13		138,104	150,904			
4/16		390,472	826,440			
4/19		340,528	404,624			
4/23		442,272	1,662,080			
4/26		702,048	920,032			
4/30		1,005,776	1,141,216			
5/ 3		993,276	1,284,204			
5/ 7		769,344	822,240			
5/11		907,232	1,277,504			
5/14		1,854,560	1,966,752			
5/17		3,345,248	3,927,104			
5/21		2,280,928	2,502,112			
5/24		2,016,448	2,280,928			
5/27		2,125,440	2,657,600			
5/31		2.107,456	3,647,840			
6/ 3		2,962,176	3,709,120			
6/ 7		3,920,714	4,925,738			
6/11		3,074,368	4,185,184			
6/16		3,547,172	5,044,260			
6/18		2,915,680	4,419,168			
6/21		3,887,008	4,587,456			
6/25		4,306,576	5,753,968			
6/28		3,544,032	5,411,392			
7/ 3		2,601,504	5,542,784			
7/ 5		3,560,032	5,629,376			
7/ 9		1,804,864	4,821,440			
7/12		905,632	7,100,864			
7/16		1,757,368	7,109,464			
7/19		1,434,592	8,476,160			
7/23		899,232	4,185,184			
7/26		2,125,440	10,324,320			
7/30		1,535,488	5,779,968			
8/ 2		3,547,232	8,379,968			
8/ 6		1,114,016	6,102,240			
8/ 9		2,277,728	5,190,208			
8/13		5,666,262	14,152,012			
8/15		3,398,144	10,178,432		6,400	6,400
8/20		2,284,128	12,757,536			
8/23		2,987,776	11,880,704		6,400	6,400
8/27		1,235,808	9,755,264			
8/31		2,980,176	14,299,920			
9/ 2		1,430,992	16,634,544	12,800	6,400	19,200
9/ 6	3,200	1,705,472	18,529,600			
9/ 9		1,226,208	23,872,096			
9/13		1,248,608	22,883,072			
9/17		1,289,688	22,502,200			
9/20		1,328,192	10,902,368			
9/24		1,434,592	8,899,328			
9/27		1,163,712	15,868,800			
10/ 1		2,168,736	14,546,400			
10/ 4		1,440,992	8,071,192			
10/ 8		1,394,496	7,854,208		6,400	6,400
10/11		1,804,864	8,740,640			
10/15	6,400	1,335,200	5,355,224		105,792	105,792

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Total Suctoria	Total Protozoa without Mastigophora	Total Protozoa with Mastigophora	Collotheca egg, attached	Collotheca pelagica	Total Rhizota
10/18		1,223,008	7,676,320			
10/22		4,020,096	9,838,656	6,400	6,400	12,800
10/26		2,591,914	7,617,034			
10/29		3,377,436	10,636,988			
11/ 1		1,753,750	9,806,752			
11/ 5		5,339,104	10,946,080			
11/ 8		1,746,488	8,119,608			
11/12		5,565,184	19,430,336			
11/15	6,400	2,279,232	9,644,576			
11/19	52,896	1,718,272	7,386,144			
11/22		424,672	6,239,184			
11/26		297,232	2,841,040			
11/30		957,680	4,274,880			
12/ 3	3,200	478,320	3,258,560			
12/ 6	3,200	267,488	2,340,032			
12/10	2 400	116,992	1,141,852			
12/14		471,018	1,690,826			
12/17	800	449,192	1,878,584			
12/20		721,508	1,469,628			
12/24	800	143,392	1,283,856			
12/27		298,128	1,647,776			
12/31		350,436	1,389,720			

1913	Rotaria neptunia	Rotaria rotatoria	Rotifer egg, winter	Rotifer egg unidentified	Rotifer unidentified	Total Bdelloida
1/ 5	3,200	112,404				115,604
1/ 8		213,420				231,420
1/12		178,524				178,524
1/15	2,000	449,616				451,616
1/19	7,200	720,708				727,908
1/22	8,000	185,136				193,136
1/26	39,672	1,309,176			26,448	1,375,496
1/29	39,672	1,243,056			46,284	1,329,012
2/ 2	8,000	1,282,728	400		3,200	1,293,928
2/ 5	25,600	1,335,624			800	1,361,024
2/ 8	11,200	1,203,384	800	79,344		1,284,728
2/12	25,600	1,626,552	800	145,464	66,120	1,864,536
2/15	24,000	1,401,744		800	3,200	1,428,744
2/19	11,200	357,048			1,600	369,848
2/23		674,424	39,672		1,600	676,024
2/26	3,200	1,057,920	1,600		3,200	1,064,320
3/ 1	3,200	1,745,568			6,400	1,755,168
3/ 5		1,639,776			52,896	1,692,672
3/ 8		766,992	1,600		1,600	768,592
3/12	3,200	2,512,560			105,792	2,681,552
3/15		1,269,504			6,400	1,275,904
3/19	3,200	714,096			3,200	720,496
3/23	3,200	793,440		1,600	1,600	798,240
3/26		343,824				343,824
3/29	6,400	528,960			52,896	588,256
4/ 2		79,344			3,200	82,544
4/ 5		290,928				290,928
4/ 9		317,376			132,240	449,616
4/13		132,240			3,200	135,440
4/16		185,136			1,600	186,736
4/19		105,792		1,600		105,792
4/23		79,344		1,600	1,600	80,944
4/26		3,200			1,600	4,800

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Rotaria neptunia	Rotaria rotatoria	Rotifer egg, winter	Rotifer egg, unidentified	Rotifer unidentified	Total Bdelloida
4/30		79,344			79,344	158,688
5/ 3		79,344			158,688	238,032
5/ 7		105,792			1,600	107,392
5/11		1,600				1,600
5/14		6,400		6,400	6,400	12,800
5/17		370,272	6,400		211,584	581,856
5/21		3,200			264,480	267,680
5/24		25,600			264,480	290,080
5/27		6,400				6,400
5/31		6,400			6,400	12,800
6/ 3		6,400			3,200	9,600
6/ 7					6,400	6,400
6/11					3,200	3,200
6/16					12,800	12,800
6/18		19,200			3,200	22,400
6/21		19,200			6,400	25,600
6/25		158,688		3,200	6,400	165,088
6/28		423,168				423,168
7/ 3	6,400	158,688				165,088
7/ 5		19,200			158,688	177,888
7/ 9		6,400			3,200	9,600
7/12		211,584			3,200	214,784
7/16		19,200			19,200	38,400
7/19					158,688	158,688
7/23		317,376				317,376
7/26		12,800			26,500	38,400
7/30	6,400	6,400			3,200	16,000
8/ 2	6,400	32,000	19,200		3,200	41,600
8/ 6	6,400	32,000	3,200		211,584	249,984
8/ 9	6,400	370,272	264,480			376,672
8/13		105,792			317,376	105,792
8/15	57,600	153,600			317,376	528,576
8/20	25,600	237,184			158,688	262,784
8/23	12,800	16,000			6,400	35,200
8/27	32,000	105,792			158,688	296,480
8/31					105,792	105,792
9/ 2					3,200	3,200
9/ 6		6,400			105,792	112,192
9/ 9			3,200		3,200	3,200
9/13		12,800			105,792	118,592
9/17						
9/20	12,800	211,584			6,400	230,784
9/24	12,800	6,400				19,200
9/27						
10/ 1		52,896				52,896
10/ 4	25,600	6,400				32,000
10/ 8	6,400	12,800	6,400		211,584	230,784
10/11	6,400				105,792	112,192
10/15	158,688	65,696			211,584	435,968
10/18	38,400	19,200				57,600
10/22	12,800	105,792			264,480	389,472
10/26	19,200	19,200	6,400		52,896	91,296
10/29	19,200	25,600			211,584	256,384
11/ 1	76,800	211,584			105,792	394,176
11/ 5	158,688	158,688				317,376
11/ 8	105,792	105,792				211,584
11/12	105,792	79,344				186,136
11/15	6,400	105,792	6,400			112,192
11/19	19,200	317,376	3,200		52,896	489,472
11/22	12,800	132,240	6,400		52,896	207,936

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Rotaria neptunia	Rotaria rotatoria	Rotifer egg, winter	Rotifer egg, unidentified	Rotifer unidentified	Total Bdelloida
11/26	52,896	51,200	9,600			104,096
11/30	16,000	79,344	52,896		1,600	96,944
12/ 3	52,896	79,344				132,240
12/ 6	41,600	185,136	1,600			226,736
12/10	19,826	19,836				39,672
12/14	33,060	800	400			33,860
12/17	33,060	1,600	400			34,660
12/20	52,896	13,224	400			66,120
12/24	4,800		800			4,800
12/27	13,224	26,448				39,672
12/31	52,896	39,672	1,600		400	92,968

1913	Anuraeopsis egg, attached	Anuraeopsis fissa	Anuraeopsis sp	Asplanchna brightwellii	Asplanchnopus sp	Brachionus angularis
1/ 5						
1/ 8						
1/12						
1/15						
1/19						
1/22						
1/26						
1/29						
2/ 2						
2/ 5						
2/ 8						
2/12					1,600	
2/15					800	
2/19						
2/23						
2/26						
3/ 1						
3/ 5						6,400
3/ 8						
3/12						
3/15				16,000		
3/19				16,000		3,200
3/23				3,200		
3/26						1,600
3/29				9,600		
4/ 2				9,600		6,400
4/ 5				83,200	3,200	
4/ 9				132,240		
4/13				41,600		
4/16				41,600		
4/19				35,200		
4/23				16,000		3,200
4/26				41,600		12,800
4/30				9,600		132,240
5/ 3						185,136
5/ 7				12,800		264,480
5/11				44,800		978,576
5/14				12,800		1,428,192
5/17			264,480			1,057,920
5/21			423,168	25,600		370,272
5/24			158,688	12,800		423,168
5/27			3,200	51,200		179,200
5/31				12,800		581,856
6/ 3				19,200		476,064

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Anuraeopsis egg, attached	Anuraeopsis fissa	Anuraeopsis sp	Asplanchna brightwellii	Asplanchnopus sp	Brachionus angularis
6/ 7				44,800		158,688
6/11				32,000		370,272
6/16				19,200		264,480
6/18				6,400		19,200
6/21			6,400	6,400		
6/25				51,200		3,200
6/28				38,400		
7/ 3				83,200		12,800
7/ 5				158,688		3,200
7/ 9				19,200		
7/12				44,800		158,688
7/16				12,800		
7/19				6,400		
7/23		6,400		3,200		
7/26				19,200		
7/30				25,600		
8/ 2				44,800		
8/ 6						
8/ 9		6,400				3,200
8/13	6,400	38,400		38,400		
8/15		6,400		76,800		
8/20		12,800		25,600		
8/23		3,200		25,600		
8/27				32,000		
8/31		19,200		6,400		
9/ 2		6,400		12,800		
9/ 6						
9/ 9				6,400		
9/13		3,200		51,200		
9/17		6,400		3,200		
9/20						52,896
9/24	6,400	105,792				105,792
9/27						370,272
10/ 1	52,896	52,896				317,376
10/ 4		6,400				
10/ 8	6,400	19,200				52,896
10/11				6,400		
10/15		12,800		19,200		
10/18		105,792		6,400		
10/22	6,400	12,800		57,600		
10/26		6,400		12,800		
10/29	6,400	108,800		105,792		
11/ 1	6,400	158,688		6,400		
11/ 5						
11/ 8						
11/12						3,200
11/15		12,800				19,200
11/19	41,600	54,400				22,400
11/22	52,896	158,688				79,344
11/26		132,240				16,000
11/30		6,400				3,200
12/ 3		3,200				3,200
12/ 6						
12/10						
12/14						
12/17						
12/20						
12/24						
12/27						
12/31						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Brachionus angularis caudatus	Brachionus budapestenensis	Brachionus calyciflorus	Brachionus capsuliflorus	Brachionus egg, attached female	Brachionus egg, attached male
1/ 5			6,612			
1/ 8			39,672		400	
1/12		9,600	10,000		2,400	
1/15			13,224		1,200	8,400
1/19			13,224		800	5,200
1/22			800		4,800	
1/26			19,836		19,836	
1/29			59,508		1,600	
2/ 2			33,060		33,060	39,672
2/ 5			52,896		85,956	79,344
2/ 8			171,912		79,344	52,896
2/12			224,808		224,808	105,792
2/15			9,600			6,400
2/19			66,120		39,672	
2/23			211,584		304,152	
2/26			396,720		528,960	16,000
3/ 1			317,376		290,928	12,800
3/ 5			1,295,952		1,375,296	317,376
3/ 8			1,110,816		714,096	79,344
3/12			3,914,304		608,304	476,064
3/15			132,240		92,800	48,000
3/19			264,480		105,792	
3/23			449,616		132,240	32,000
3/26			343,824		317,376	32,000
3/29			264,480	1,600	290,928	
4/ 2			714,096		185,136	290,928
4/ 5			317,376		3,200	
4/ 9			16,000			
4/13			19,200		12,800	
4/16			79,344		52,896	
4/19			38,400		9,600	
4/23			44,800		12,800	52,896
4/26			57,600		9,600	
4/30			25,600		61,600	
5/ 3	12,800		105,792		79,344	
5/ 7			185,136	6,400	502,512	
5/11			79,344		238,032	
5/14			140,800	12,800	370,272	6,400
5/17			102,400	6,400	423,168	
5/21	12,800		44,800		211,584	
5/24	12,800		6,400		317,376	
5/27	25,600				423,168	44,800
5/31	211,584				211,584	
6/ 3	581,856				899,232	3,200
6/ 7	952,128				476,064	
6/11	370,272			6,400	288,000	
6/16	317,376				952,128	[illegible]
6/18	899,232				370,272	
6/21	1,110,816				793,440	[illegible]
6/25	2,591,904			6,400	846,336	317,376
6/28	1,269,504			6,400	528,960	
7/ 3	687,648				158,688	
7/ 5	476,069				158,688	
7/ 9	1,163,712		3,200		687,648	
7/12	1,375,296				528,960	
7/16	793,440				846,336	
7/19	793,440				476,064	
7/23	317,376			6,400	158,688	
7/26	1,481,088		6,400		370,272	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Brachionus angularis caudatus	Brachionus budapestenensis	Brachionus calyciflorus	Brachionus capsuliflorus	Brachionus egg, attached female	Brachionus egg, attached male
7/30	423,168			6,400	12,800	
8/ 2	211,584				2,644,480	
8/ 6	105,792				3,200	
8/ 9	105,792				158,688	105,792
8/13	1,269,504				317,376	
8/15	1,428,192			6,400	687,648	
8/20	1,692,672			6,400	952,128	
8/23	899,232				740,544	
8/27	952,128				476,064	
8/31	317,376				105,792	
9/ 2	476,064			6,400	158,688	
9/ 6	476,064				317,376	105,792
9/ 9	2,433,216			3,200	1,269,504	19,200
9/13	2,062,944			3,200	476,064	
9/17	687,648		6,400		370,272	
9/20	19,200				6,400	
9/24	264,480		12,800		105,792	
9/27	740,544				1,005,024	
10/ 1	581,856	19,200		12,800	370,272	
10/ 4	581,856	6,400	6,400	6,400	423,168	
10/ 8	793,440			32,000	634,752	52,896
10/11	423,168	52,896	6,400	6,400	158,688	
10/15	264,480			6,400	158,688	19,200
10/18	158,688	6,400		32,000	52,896	
10/22	370,272		6,400		211,584	211,584
10/26	19,200					
10/29	25,600	6,400		6,400	6,400	
11/ 1				6,400		
11/ 5	6,400		6,400			
11/ 8						
11/12			3,200		9,600	9,600
11/15			6,400		12,800	12,800
11/19			3,200		19,200	
11/22			3,200		105,792	
11/26			9,600		79,344	
11/30					16,000	
12/ 3					9,600	
12/ 6						
12/10					1,600	
12/14					800	
12/17						
12/20			800			
12/24					1,600	
12/27						
12/31						

1913	Brachionus egg, free female	Brachionus egg, free male	Brachionus male	Brachionus plicatilis	Brachionus urceus	Brachionus with endoparasites
1/ 5	13,224			1,600	6,612	
1/ 8	33,060			2,000	400	
1/12	6,400			5,200	800	
1/15	26,448			13,224	400	
1/19	13,224			26,448		
1/22	400			4,800	1,600	
1/26				26,448	400	
1/29	19,836			52,896	17,600	
2/ 2	13,224			92,568	59,508	
2/ 5	92,568			99,180	52,896	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Brachionus egg, free female	Brachionus egg, free male	Brachionus male	Brachionus plicatilis	Brachionus urceus	Brachionus with endoparasites
2/ 8	119,016			79,344	52,896	
2/12	39,672			132,240	105,792	
2/15				1,600	3,200	
2/19	92,568			3,200		
2/23	171,912	800		17,600	800	
2/26	105,792	1,600		16,000	79,344	
3/ 1	52,896			25,600		
3/ 5	211,584	79,344		132,240	6,400	
3/ 8	52,896			12,800		
3/12	476,064	1,600	1,600	38,400		
3/15			6,400	19,200		
3/19	158,688	1,600		12,800		
3/23	185,136			6,400		
3/26	264,480			22,400	3,200	
3/29	211,584			25,600	3,200	
4/ 2	132,240			9,600		
4/ 5	52,896			19,200		
4/ 9	1,600				3,200	
4/13				3,200		
4/16						
4/19	1,600					
4/23	3,200					
4/26	1,600			3,200		
4/30	1,600					
5/ 3					3,200	
5/ 7				1,600		
5/11	423,168					
5/14	423,168				25,600	
5/17	1,005,024				32,000	
5/21	211,584				158,688	
5/24	211,584				128,000	
5/27	211,584			12,800	423,168	
5/31	317,376				370,272	
6/ 3	158,688		211,584		899,232	
6/ 7	211,584		3,200		740,544	
6/11	317,376				505,600	
6/16	370,272				423,168	
6/18	317,376				687,648	
6/21	317,376			3,200	899,232	
6/25	581,856				581,856	528,960
6/28	687,648			6,400	128,000	
7/ 3	264,480				51,200	
7/ 5	1,005,024			6,400	44,800	
7/ 9	899,232				44,800	
7/12	1,005,024				528,960	
7/16	370,272				528,960	
7/19	264,480				370,272	
7/23	740,544				6,400	
7/26	476,064				423,168	
7/30	423,168				105,792	12,800
8/ 2	423,168				370,272	3,200
8/ 6	634,752				264,480	6,400
8/ 9	1,163,712			6,400	793,440	
8/13	1,110,816		105,792		793,440	
8/15	899,232				264,480	
8/20	2,486,112				476,064	
8/23	634,752				581,856	
8/27	1,005,024				370,272	
8/31	687,648				105,792	

Table 1.—Organisms Per Cubic Meter in Plankton of Stockton Channel in 1913—(*Continued*)

1913	Brachionus egg, free female	Brachionus egg, free male	Brachionus male	Brachionus plicatilis	Brachionus urceus	Brachionus with endoparasites
9/ 2	634,752				96,000	
9/ 6	846,336				105,792	
9/ 9	793,440				211,584	
9/13	1,057,920				211,584	
9/17	370,272				12,800	
9/20	687,648				19,200	
9/24	476,064				121,600	
9/27	370,272				264,480	
10/ 1	370,272				158,688	
10/ 4	952,128				105,792	
10/ 8	793,440				158,688	6,400
10/11	952,128				105,792	
10/15	634,752				211,584	
10/18	952,128				44,800	
10/22	528,960				32,000	
10/26	264,480			6,400	6,400	
10/29	317,376				12,800	
11/ 1	105,792			6,400		
11/ 5	105,792					
11/ 8	158,688					
11/12	52,896					
11/15					52,896	
11/19	238,032				3,200	
11/22	370,272				9,600	
11/26	132,240				1,600	
11/30	449,616				6,400	
12/ 3	449,616				3,200	
12/ 6	158,688				3,200	
12/10	46,284				800	
12/14	119,016				1,600	
12/17	33,060					
12/20	66,120					
12/24	26,448				800	
12/27	72,732					
12/31	105,792					

1913	Diurella egg, free	Diurella tenuior	Epiphanes clavulata	Filinia brachiata	Filinia egg, attached female	Filinia egg, attached male
1/ 5						
1/ 8						
1/12						
1/15						
1/19						
1/22						
1/26						
1/29						
2/ 2					400	2,400
2/ 5						
2/ 8						
2/12					92,568	
2/15					26,448	
2/19					158,688	
2/23					581,856	277,704
2/26					555,408	79,344
3/ 1					105,792	132,240
3/ 5					1,481,088	502,512
3/ 8					423,168	238,032
3/12					1,190,160	105,792

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Diurella egg, free	Diurella tenuior	Epiphanes clavulata	Filinia brachiata	Filinia egg, attached female	Filinia egg, attached male
3/15		3,200			132,240	
3/19					185,136	158,688
3/23					117,376	
3/26					132,240	
3/29					476,064	52,896
4/ 2					132,240	
4/ 5					52,896	
4/ 9					1,600	
4/13				1,600	185,136	
4/16					79,344	
4/19					1,600	
4/23					158,688	
4/26		3,200			317,376	132,240
4/30						
5/ 3					158,688	211,584
5/ 7					502,512	185,136
5/11					158,688	105,792
5/14					211,584	
5/17					105,792	
5/21				12,800		
5/24				6,400		
5/27	105,792			3,200	3,200	
5/31	105,792					
6/ 3					105,792	
6/ 7				6,400		
6/11						
6/16	3,200					
6/18	3,200				6,400	
6/21						
6/25					3,200	
6/28				6,400	211,584	317,376
7/ 3					3,200	
7/ 5				3,200	158,688	
7/ 9	3,200				3,200	
7/12						
7/16						
7/19					6,400	
7/23						
7/26						
7/30						
8/ 2	105,792					
8/ 6						
8/ 9						
8/13						
8/15						
8/20			6,400			
8/23			6,400			
8/27						
8/31						
9/ 2						
9/ 6						
9/ 9						
9/13						
9/17						
9/20						
9/24			6,400			
9/27						
10/ 1						
10/ 4			6,400			
10/ 8						

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Diurella egg, free	Diurella tenuior	Epiphanes clavulata	Filinia brachiata	Filinia egg, attached female	Filinia egg, attached male
10/11						
10/15	52,896		105,792			
10/18	52,896					
10/22						
10/26						
10/29						
11/ 1						
11/ 5						
11/ 8						
11/12						
11/15						
11/19				105,792	1,600	
11/22				105,792		79,344
11/26				52,896	1,600	
11/30				1,600		
12/ 3						
12/ 6						
12/10						
12/14						
12/17						
12/20						
12/24						
12/27						
12/31						

1913	Filinia egg, free	Filinia longiseta	Keratella cochlearis	Keratella egg, attached	Keratella egg, free	Keratella male
1/ 5		72,732			72,732	
1/ 8		20,800		400	79,344	
1/12		5,600	400	6,000	25,200	
1/15		26,448	13,224	26,448	99,180	
1/19		2,400	400	26,448	46,284	
1/22		1,600	33,060	19,836	39,672	
1/26		800		72,732	138,852	
1/29		46,284	800	112,404	125,628	
2/ 2		4,800	13,224	33,060	171,912	
2/ 5		13,600	800	39,672	145,464	
2/ 8		66,120	800	171,912	343,824	
2/12		304,152	52,896	436,392	899,232	
2/15		19,200	9,600	3,200	800	
2/19		383,496	14,400	6,400	132,240	
2/23	105,792	2,062,944	39,672	52,896	198,360	
2/26	132,240	1,401,744	79,344	79,344	449,616	
3/ 1	238,032	555,408	79,344	9,600		
3/ 5	1,904,256	3,702,720	158,688	1,600	79.344	
3/ 8	793,440	6,083,040	105,792	158,688	1,600	
3/12	899,232	5,025,120	105,792	1,600		
3/15	290,928	1,110,816	28,800	1,600	1,600	
3/19	449,616	1,586,880	343,824	290,928	1,600	
3/23	211,584	978,576	211,584	211,584	79,344	
3/26	52,896	608,304	238,032	423,168	396,720	
3/29	52,896	608,304	158,688	555,408	740,544	
4/ 2		238,032	370,272	132,240	2,089,392	
4/ 5		238,032	132,240	1,454,640	872,784	
4/ 9		132,240	238,032	608,304	2,115,840	
4/13		476,064	48,000	502,512	2,115,840	
4/16		185,136	6,400	264,480	2,062,944	
4/19		264,480	211,584	925,680	1,295,952	
4/23		290,928	290,928	423,168	1,005,024	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Filinia egg, free	Filinia longiseta	Keratella cochlearis	Keratella egg, attached	Keratella egg, free	Keratella male
4/26	608,304	581,856	211,584	423,168	1,930,704	
4/30	899,232	264,480		476,064	1,533,984	
5/ 3	819,888	370,272	1,600	502,512	1,243,056	
5/ 7	819,888	1,930,704	105,792	1,005,024	2,036,496	
5/11	502,512	925,128	52,896	819,888	793,440	
5/14	105,792	1,639,776		370,272	476,064	
5/17	211,584	1,057,920	3,200	3,200	317,376	
5/21	581,856	158,688		158,688	476,064	
5/24	370,272	6,400			476,064	
5/27		158,688	6,400	105,792	211,584	
5/31		25,600		3,200	476,064	
6/ 3		211,584	3,200	634,752	1,322,400	
6/ 7		51,200	6,400	105,792	370,272	
6/11		6,400	3,200	105,792	3,200	
6/16	105,792	38,400	19,200	158,688	264,480	
6/18	3,200	51,200	158,688	476,064	528,960	
6/21	158,688	211,584	6,400	211,584	1,586,880	
6/25	3,200	423,168	211,584	1,533,984	1,533,984	158,688
6/28	105,792	1,110,816	317,376	1,957,152	1,481,088	
7/ 3	158,688	264,480	264,480	317,376	3,200	
7/ 5	370,272	1,375,296	793,440	211,584	476,064	
7/ 9	476,064	12,800	211,584	3,200	211,584	
7/12	370,272	105,792	423,168	3,200	687,648	
7/16		25,600	12,800	105,792		
7/19	105,792	6,400	32,000	211,584	105,792	
7/23	105,792		38,400	211,584		
7/26	211,584		6,400	264,480		3,200
7/30	158,688		12,800	105,792	3,200	
8/ 2				158,688	105,792	
8/ 6	3,200			3,200		
8/ 9	264,480			105,792	264,480	
8/13	423,168			105,792	3,200	
8/15	370,272			3,200	3,200	
8/20	476,064				3,200	
8/23	158,688			317,376		
8/27	158,688			3,200		
8/31	264,480			3,200		
9/ 2	105,792			12,800		
9/ 6	3,200			105,792	3,200	
9/ 9	3,200			3,200		
9/13	3,200			423,168		
9/17			6,400	3,200		
9/20				12,800		
9/24	52,896			52,896		
9/27	52,896			370,272		
10/ 1	52,896		6,400	634,752		
10/ 4	105,792			793,440		
10/ 8				1,798,464		
10/11				1,216,608		
10/15	211,584		52,896	1,216,608		
10/18	52,896		158,688	423,168		
10/22	52,896		264,480	634,752	370,272	
10/26			528,960	423,168	158,688	
10/29	158,688		423,168	476,064	158,688	
11/ 1	211,584		105,792	6,400	105,792	
11/ 5			211,584	6,400		
11/ 8			89,600	25,600		
11/12			132,240	52,896	79,344	
11/15	105,792		51,200	12,800	581,856	
11/19	132,240		52,896	28,800	714,096	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Filinia egg, free	Filinia longiseta	Keratella cochlearis	Keratella egg, attached	Keratella egg, free	Keratella male
11/22	185,136		48,000	22,400	423,168	
11/26			51,200	28,800	79,344	
11/30	105,792		52,896	19,200	105,792	
12/ 3	52,896	1,600	57,600	52,896	52,896	
12/ 6			3,200	52,896	52,896	
12/10			1,600	6,400		
12/14	19,836		800	72,732	46,284	
12/17			1,600	4,000	1,600	
12/20				46,284	19,836	
12/24		1,600		13,224	19,836	
12/27			1,600	26,448	39,672	
12/31				66,120	79,344	

1913	Keratella quadrata	Lecane luna	Notholca striata	Notommata aurita	Polyarthra trigla	Polyarthra trigla egg attached female
1/ 5	26,448					
1/ 8	92,568					
1/12	79,344				1,200	
1/15	152,076				39,672	
1/19	85,956		400	400	800	
1/22	39,672		800		800	
1/26	231,420				19,836	
1/29	323,928				66,120	
2/ 2	198,360				1,600	
2/ 5	125,628				19,836	
2/ 8	423,168				105,792	
2/12	1,124,040				39,672	
2/15	11,200				4,800	
2/19	79,344				14,400	
2/23	251,256	1,600			105,792	
2/26	132,240				28,800	3,200
3/ 1	16,000			6,400	79,344	
3/ 5	41,600	1,600			370,272	
3/ 8	925,680				581,856	
3/12	317,376				158,688	
3/15	313,824		3,200		238,032	3,200
3/19	952,128				132,240	
3/23	740,544		3,200		25,600	
3/26	1,084,368				79,344	52,896
3/29	2,142,288				105,792	1,600
4/ 2	3,385,344				158,688	
4/ 5	4,205,232				396,720	52,896
4/ 9	3,041,520				1,110,816	158,688
4/13	925,680				1,560,432	290,928
4/16	1,719,120		3,200		766,992	1,600
4/19	4,205,232				1,772,016	555,408
4/23	2,195,184				370,272	158,688
4/26	2,459,664				2,644,800	132,240
4/30	2,010,048				2,062,944	528,960
5/ 3	1,613,328				1,216,608	238,032
5/ 7	3,067,968				3,147,312	105,792
5/11	5,104,464				2,724,144	185,136
5/14	2,909,280				528,960	
5/17	1,005,024				264,480	
5/21	1,322,400				57,600	
5/24	317,376				38,400	
5/27	740,544				19,200	
5/31	846,336				19,200	
6/ 3	1,533,984				105,792	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Keratella quadrata	Lecane luna	Notholca striata	Notommata aurita	Polyarthra trigla	Polyarthra trigla egg, attached female
6/ 7	846,336				6,400	
6/11	528,960				19,200	
6/16	317,376	6,400			51,200	
6/18	740,544				317,376	
6/21	1,798,464				476,064	
6/25	6,030,144				1,005,024	
6/28	7,035,168				687,648	
7/ 3	1,798,464				19,200	
7/ 5	1,163,712				158,688	
7/ 9	264,480				899,232	3,200
7/12	1,322,400				1,692,672	3,200
7/16	952,128				687,648	
7/19	846,336				158,688	
7/23	1,692,672				134,400	
7/26	2,062,944				634,752	
7/30	2,010,048				952,128	
8/ 2	1,110,816				793,440	3,200
8/ 6	687,648				687,648	
8/ 9	740,544				2,327,424	
8/13	899,232				952,128	
8/15	423,168				1,057,920	
8/20	1,163,712				1,904,256	
8/23	1,904,256		6,400		1,428,192	
8/27	528,960				952,128	12,800
8/31	581,856				581,856	
9/ 2	158,688				952,128	3,200
9/ 6	317,376				264,480	
9/ 9	899,232				846,336	105,792
9/13	1,957,152				1,057,920	105,792
9/17	1,005,024				264,480	
9/20	89,600				899,232	
9/24	846,336				581,856	52,896
9/27	1,322,400				740,544	52,896
10/ 1	1,533,984				476,064	
10/ 4	2,062,944				581,856	
10/ 8	5,395,392				634,752	52,896
10/11	4,866,432				634,752	105,792
10/15	3,914,304				634,752	
10/18	2,010,048				740,544	
10/22	2,697,696				423,168	
10/26	952,128				44,800	
10/29	1,269,504				32,000	
11/ 1	581,856				158,688	
11/ 5	64,000					
11/ 8	19,200				52,896	
11/12						
11/15	12,800				6,400	19,200
11/19	25,600				476,064	264,480
11/22	12,800				158,688	19,200
11/26	25,600				185,136	108,800
11/30	38,400				528,960	132,240
12/ 3	79,344				264,480	28,800
12/ 6	35,200				449,616	52,896
12/10	33,060				46,284	1,600
12/14	132,240				495,900	66,120
12/17	33,060				66,120	13,224
12/20	92,568				66,120	13,224
12/24	46,284				5,600	
12/27	85,956	400			46,284	800
12/31	125,628				132,240	1,600

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Polyarthra trigla egg, attached male	Synchaeta sp	Trichocerca capucina	Trichocerca iernis	Total Ploima	Total Ploima without eggs
1/ 5					199,960	114,004
1/ 8					268,644	155,440
1/12					142,544	102,544
1/15					419,944	258,268
1/19					221,984	130,028
1/22		800			148,640	83,932
1/26					530,960	301,540
1/29		800			827,464	567,996
2/ 2					696,848	403,120
2/ 5					807,840	364,836
2/ 8					1,667,024	900,032
2/12					3,783,664	1,985,200
2/15					96,848	60,000
2/19					990,528	560,960
2/23		1,600			4,386,320	2,692,848
2/26		3,200			4,058,896	2,107,392
3/ 1		3,200			1,924,960	1,082,672
3/ 5		6,400			11,674,672	5,722,272
3/ 8					11,317,848	8,856,584
3/12		6,400			13,336,096	9,577,280
3/15		6,400			2,468,480	1,898,112
3/19					4,663,600	3,311,552
3/23					3,587,984	2,618,720
3/26		9,600			4,062,448	2,390,672
3/29		16,000			5,717,472	2,525,552
4/ 2		6,400			7,860,608	4,898,432
4/ 5		3,200			7,887,712	5,398,400
4/ 9		52,896			7,612,976	4,726,944
4/13					6,182,992	3,075,776
4/16					5,263,056	2,801,792
4/19					9,316,752	6,526,912
4/23					5,025,776	3,211,312
4/26		1,600			9,573,136	6,017,904
4/30		3,200			8,009,552	4,508,062
5/ 3		6,400			6,757,440	3,504,336
5/ 7		52,896			13,932,448	8,775,088
5/11		1,600			13,163,008	9,936,352
5/14					8,664,960	6,701,408
5/17		44,800			5,911,168	3,845,024
5/21		317,376			5,143,968	3,504,192
5/24		70,400			2,556,128	1,180,832
5/27		44,800		12,800	2,786,620	1,786,492
5/31		12,800			3,194,464	2,186,240
6/ 3		317,376			7,483,936	4,359,872
6/ 7		32,000	6,400		4,018,208	2,854,496
6/11					2,556,672	1,842,304
6/16		3,200			3,464,960	1,466,400
6/18		211,584			4,797,336	3,085,064
6/21		317,376			7,916,704	4,835,936
6/25		2,644,800	6,400		18,537,504	13,717,568
6/28		1,745,568	6,400		17,647,680	12,358,080
7/ 3		32,000		6,400	4,125,504	3,219,872
7/ 5		528,960		19,200	7,111,968	4,731,648
7/ 9		12,800		211,584	5,127,720	2,843,592
7/12		3,200		317,376	8,578,056	5,979,752
7/16		6,400		6,400	4,348,576	3,026,176
7/19				6,400	3,390,048	2,219,936
7/23		6,400			3,428,256	2,208,448
7/26				12,800	5,972,352	4,649,952
7/30				19,200	4,255,784	3,552,136
8/ 2				19,200	3,639,032	2,683,704

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Polyarthra trigla egg, attached male	Synchaeta sp	Trichocerca capucina	Trichocerca iernis	Total Ploima	Total Ploima without eggs
8/ 6				158,688	2,551,808	1,907,456
8/ 9		12,800		105,792	6,029,196	3,966,252
8/13				19,200	6,082,848	4,116,096
8/15				105,792	5,332,704	3,369,152
8/20					9,205,408	5,287,904
8/23		6,400		3,200	6,716,096	4,864,736
8/27					4,491,296	2,835,520
8/31		6,400		12,800	2,686,400	1,625,280
9/ 2				6,400	2,630,112	1,714,880
9/ 6		6,400			2,551,808	1,170,112
9/ 9					6,597,504	4,403,168
9/13				6,400	7,419,744	5,353,600
9/17					2,736,096	1,992,352
9/20					1,786,976	1,080,128
9/24				19,200	2,812,200	2.065,256
9/27				52,896	5,342,496	3,491,136
10/ 1		52,896		6,400	4,699,648	3,218,560
10/ 4				105,792	5,744,868	3,470,340
10/ 8			6,400	6,400	10,444,416	7,105,568
10/11				12,800	8,548,256	6,115,040
10/15		19,200		52,896	7,588,032	5,347,200
10/18		158,688			4,956,032	3,474,944
10/22		105,792			5,980,266	3,963,818
10/26		6,400			2,436,224	1,589,888
10/29		44,800		52,896	3,209,776	2,086,160
11/ 1					1,460,192	1,024,224
11/ 5					400,576	288,384
11/ 8		6,400			352,384	168,096
11/12		105,792		3,200	451,968	247,632
11/15		105,792			1,018,136	272,888
11/19		52,896			2,242,896	802,848
11/22		132,240			1,972,960	714,752
11/26	28,800	12,800			955,600	496,672
11/30	6,400	79,344			1,618,336	783,296
12/ 3		79,344			1,121,872	475,168
12/ 6		52,896			853,088	535,712
12/10		33,060			171,088	114,804
12/14	400	92,568			1,048,696	723,508
12/17		39,672			192,736	140,852
12/20		79,344			384,696	239,232
12/24		39,672			155,864	94,756
12/27		33,060			306,952	167,300
12/31		79,344			592,868	340,012

1913	Total Rotifera	Bosmina longirostris	Bosmina sp	Sida sp	Total Cladocera	Canthocamptus sp
1/ 5	315,564					
1/ 8	500,064					
1/12	321,068			400	400	
1/15	871,560					
1/19	949,892					
1/22	341,776					
1/26	1,906,456					
1/29	2,156,476					
2/ 2	1,990,776				800	
2/ 5	2,168,864					
2/ 8	2,951,752					
2/12	5,648,200					
2/15	1,525,692					
2/19	1,360,476					
2/23	5,062,344					

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Total Rotifera	Bosmina longirostris	Bosmina sp	Sida sp	Total Cladocera	Canthocamptus sp
2/26	5,123,216					
3/ 1	3,680,128					
3/ 5	13,367,344					
3/ 8	12,086,440					
3/12	16,017,648					
3/15	3,744,384				3,200	
3/19	5,384,096					
3/23	4,386,224					3,200
3/26	4,406,272					
3/29	6,305,728					
4/ 2	7,943,152					
4/ 5	8,178,640					3,200
4/ 9	8,062,592					
4/13	6,318,432					
4/16	5,449,792					
4/19	9,422,544					
4/23	5,106,720					
4/26	9,577,936					
4/30	8,168,240					
5/ 3	6,995,472					
5/ 7	14,039,840					
5/11	13,164,608					
5/14	8,677 760					
5/17	6,493,024		3,200		3,200	
5/21	5,411,648					
5/24	2,846,208		6,400		6,400	
5/27	2,793,020					
5/31	3,207,264					
6/ 3	7 493,536			6 400	6,400	
6/ 7	4,024,608			6,400	6,400	
6/11	2,559,872			6,400	6,400	
6/16	3,477,760					
6/18	4,819,736					
6/21	7,942,304			6,400	6,400	
6/25	18,702,592			6,400	6,400	
6/28	18,070,648					
7/ 3	4,290,592					
7/ 5	7,289,856			6,400	6,400	
7/ 9	5,137,320					
7/12	8,792,840			6,400	6,400	
7/16	4,386,976					
7/19	3,548,736			12,800	12,800	
7/23	3,745,632					
7/26	6,010,752			6,400	6,400	
7/30	4,271,784	6,400			6,400	
8/ 2	3,680,632	6,400		6,400	12,800	
8/ 6	2,801,792					
8/ 9	6,405,868			6,400	6,400	
8/13	6,188,640					
8/15	5,867,680					
8/20	9,467,192	3,200			3,200	
8/23	6,757,696			19,200	19,200	
8/27	4,787,776			6,400	6,400	
8/31	2,792,192			6,400	6,400	
9/ 2	2,652,512			25,600	25,600	
9/ 6	2,644,000					
9/ 9	6,600,704	6,400		6,400	12,800	
9/13	7,638,336					
9/17	2,736,096	6,400		12,800	19,200	
9/20	2,017,760					
9/24	2,831,400	6,400		12,800	19,200	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Total Rotifera	Bosmina longirostris	Bosmina sp	Sida sp	Total Cladocera	Canthocamptus sp
9/27	5,342,496			12,800	12,800	
10/ 1	4,752,544	19,200		105,792	124,992	
10/ 4	5,776,868	6,400		6,400	12,800	
10/ 8	10,681,600	12,800			12,800	
10/11	8,660,448					
10/15	8,129,792					
10/18	5,013,632			6,400	6,400	
10/22	6,382,538			6,400	6,400	
10/26	2,527,520					
10/29	3,466,160					
11/ 1	1,854,368					
11/ 5	717,952					
11/ 8	563,968					
11/12	641,304					
11/15	1,130,328					
11/19	2,732,368	3,200			3,200	
11/22	2,180,896					
11/26	1,059,696			3,200	3,200	
11/30	1,715,280					
12/ 3	1,254,112					
12/ 6	1,079,824					
12/10	210,760					
12/14	1,082,556					
12/17	227,396					
12/20	450,816	800			800	
12/24	160,664					
12/27	346,624					
12/31	685,836					

1913	Cyclops sp	Diaptomus sp	Nauplius sp	Total Copepoda	Total Entomostraca	Glochidia
1/ 5	6,612		800	7,412	7,412	
1/ 8			1,600	1,600	1,600	
1/12	800		2,400	3,200	3,600	
1/15	2,400		1,200	3,600	3,600	
1/19	2,000			2,000	2,000	
1/22						
1/26	1,600			1,600	1,600	
1/29	1,600		800	2,400	2,400	
2/ 2	2,400		2,400	4,800	5,600	
2/ 5	1,600		800	2,400	2,400	
2/ 8	1,600		2,400	4,000	4,000	
2/12	1,600		1,600	3,200	3,200	
2/15						
2/19						
2/23	1,600			1,600	1,600	
2/26						
3/ 1	3,200			3,200	3,200	
3/ 5	3,200			3,200	3,200	
3/ 8						
3/12						
3/15	6,400		6,400	12,800	16,000	
3/19	3,200		12,800	16,000	16,000	
3/23	9,600		12,800	25,600	25,600	
3/26	19,200		16,000	35,200	35,200	
3/29	9,600			9,600	9,600	
4/ 2	3,200	3,200	9,600	16,000	16,000	
4/ 5	12,800	9,600	32,000	57,600	57,600	
4/ 9	12,800	1,600	105,792	120,192	120,192	
4/13	9,600	12,800	105,792	128,192	128,192	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cyclops sp	Diaptomus sp	Nauplius sp	Total Copepoda	Total Entomostraca	Glochidia
4/16	6,400	12,800	25,600	44,800	44,800	
4/19	38,400	52,896	79,344	170,640	170,640	
4/23	22,400	6,400	132,240	161,040	161,040	
4/26	41,600	22,400	185,136	249,136	249,136	
4/30	38,400	44,800	79,344	162,544	162,544	
5/ 3	80,000	6,400	132,240	218,640	218,640	
5/ 7	73,600		185,136	258,736	258,736	
5/11	51,200		423,168	474,368	474,368	
5/14	57,600		1,005,024	1,062,624	1,062,624	
5/17	211,584		264,480	475,964	479,164	
5/21	57,600		634,752	692,352	692,352	
5/24	249,600		1,163,712	1,413,312	1,419,712	
5/27	192,000		952,128	1,144,128	1,144,128	
5/31	460,800		899,232	1,360,032	1,360,032	
6/ 3	317,376		899,232	1,216,608	1,223,008	
6/ 7	147,200		872,784	1,019,984	1,026,384	
6/11	264,480		1,375,296	1,639,776	1,646,176	
6/16	115,200		211,584	326,784	326,784	
6/18	179,200		317,376	496,576	496,576	
6/21	76.800		846,336	923,136	929,536	
6/25	317,376		528,960	846,436	852,836	
6/28	264,480		476,064	740,544	740,544	
7/ 3	179,200		423,168	602,368	602,368	
7/ 5	268,800		1,057,920	1,326,720	1,333,120	
7/ 9	370,272		1,163,712	1,533,984	1,533,984	
7/12	740,544		846,336	1,586,880	1,593,280	
7/16	454,400		793,440	1,247,840	1,247,840	
7/19	687,648		740,544	1,428,192	1,440,992	6,400
7/23	264,480		1,110,816	1,375,296	1,375,296	
7/26	264,480		687,648	952,128	958,528	
7/30	317,376		740,544	1,057,920	1,064,320	3,200
8/ 2	581,856		1,322,400	1,904,256	1,917,056	
8/ 6	264,480		1,269,504	1,533,984	1,533,984	
8/ 9	317,376	25,600	1,005,024	1,348,000	1,354,400	
8/13	1,005,024		1,692,672	2,697,696	2,697,696	
8/15	476,064		1,110,816	1,586,880	1,586,880	
8/20	740,544		846,336	1,586,880	1,590,080	3,200
8/23	476,064		846,336	1,322,400	1,341,600	
8/27	634,752		1,216,608	1,851,360	1,857,760	
8/31	317,376		793,440	1,110.816	1,117,216	
9/ 2	793,440		1,586,880	2,380,320	2,405,920	
9/ 6	264,480		1,269,504	1.533,984	1,533,984	
9/ 9	581,856		1,322,400	1,904,256	1,917,056	
9/13	476,064		1,005,024	1,481,088	1,481,088	
9/17	370,272		1,110,816	1,481,088	1,500,288	
9/20	370,272		370,272	740,544	740,544	
9/24	224,000		952,128	1,176,128	1,195,328	
9/27	317,376		687,648	1,005,024	1,017,824	
10/ 1	211,584		264,480	476,064	601,056	
10/ 4	211,584		211,584	423,168	435,968	
10/ 8	134,400		528,960	663,360	676,160	
10/11	158,688		105,792	264,480	264,480	
10/15	121,600		264,480	386,080	386,080	
10/18	64,000		158,688	222,688	229,088	
10/22	38,400		105,792	144,192	150,592	
10/26	158,688		105,792	264,480	264,480	
10/29	76,800		158,688	235,488	235,488	
11/ 1	29,600		211,584	211,584	211,584	
11/ 5	400		6,400	6.400	6,400	
11/ 8			12,800	12,800	12,800	
11/12	3,200		19,200	22,400	22,400	

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Cyclops sp	Diaptomus sp	Nauplius sp	Total Copepoda	Total Entomostraca	Glochidia
11/15	12,800		211,584	224,384	224,384	
11/19	28,800		79,344	108,144	111,344	
11/22	158,688		12,800	171,488	171,488	
11/26	57,600		52,896	110,496	113,696	
11/30	22,400		52,896	75,296	75,296	
12/ 3	79,344		132,240	211,584	211,584	
12/ 6	22,400		54,400	76,800	76,800	
12/10	52,896		8,800	61,696	61,696	
12/14	26,448		39,672	66,120	66,120	
12/17	3,200		2,400	5,600	5,600	
12/20	46,284		400	46,684	47,484	
12/24	4,000		3,200	7,200	7,200	
12/27	1,600		19,836	21,436	21,436	
12/31	4,800		12,000	16,800	16,800	

1913	Macrobiotus sp	Nematode larva	Nematode sp	Total Miscellaneous	Total Organisms
1/ 5					1,541,184
1/ 8			400	400	960,080
1/12					1,246,724
1/15		400		400	5,194,784
1/19					8,368,732
1/22					3,617,256
1/26					3,866,856
1/29					4,629,740
2/ 2					3,563,584
2/ 5					4,432,332
2/ 8	800			800	5,301,480
2/12			1,600	1,600	7,887,808
2/15					5,852,668
2/19					7,185,068
2/23					8,005,224
2/26					11,876,016
3/ 1					11,583,608
3/ 5					20,691,744
3/ 8					15,302,552
3/12					20,878,430
3/15					7,500,464
3/19					10,894,784
3/23					9,878,580
3/26					7,907,664
3/29					9,781,328
4/ 2					11,109,376
4/ 5					12,327,488
4/ 9					16,275,928
4/13					11,340,376
4/16					18,041,448
4/19					21,910,608
4/23			3,200	3,200	26,652,800
4/26					30,783,344
4/30					28,879,184
5/ 3			3,200	3,200	30,505,404
5/ 7					36,448,208
5/11					49,903,136
5/14					74,895,584
5/17			6,400	6,400	61,007,212
5/21					50,438,752
5/24					52,137,008
5/27					83,152,764
5/31					90,298,432

TABLE 1.—ORGANISMS PER CUBIC METER IN PLANKTON OF STOCKTON CHANNEL IN 1913—(*Continued*)

1913	Macrobiotus sp.	Nematode larva	Nematode sp	Total Miscellaneous	Total Organisms
6/ 3					102,283,072
6/ 7					89,267,642
6/11					84,639,968
6/16					66,351,588
6/18					79,474,408
6/21					71,200,832
6/25	3,200			3,200	85,669,652
6/28					105,512,440
7/ 3					66,694,496
7/ 5					36,946,240
7/ 9					32,992,824
7/12					48,253,984
7/16					78,756,792
7/19				6,400	50,284,514
7/23					29,064,214
7/26					53,158,602
7/30				3,200	38,088,136
8/ 2					39,749,616
8/ 6					31,442,432
8/ 9					37,449,228
8/13					71,372,480
8/15					43,499,944
8/20				3,200	50,960,344
8/23					49,818,048
8/27					54,312,736
8/31					65,254,556
9/ 2					65,343,280
9/ 6					77,865,920
9/ 9					74,010,912
9/13					72,756,816
9/17					62,833,944
9/20					53,627,768
9/24					64,570,056
9/27					62,673,664
10/ 1					67,484,896
10/ 4					44,854,524
10/ 8					58,332,396
10/11					58,491,488
10/15					56,239,096
10/18					52,299,264
10/22					59,089,962
10/26					55,197,450
10/29					59,191,148
11/ 1			6,400	6,400	35,026,646
11/ 5					31,695,424
11/ 8					22,527,832
11/12					47,239,288
11/15					26,993,280
11/19					23,289,272
11/22					23,203,120
11/26					15,874,240
11/30					18,297,984
12/ 3					18,520,416
12/ 6					13,329,568
12/10					5,559,302
12/14					7,442,442
12/17					6,341,848
12/20					6,567,456
12/24					3,734,436
12/27					7,168,872
12/31					6,219,632

TABLE 2—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913

1913	Spirillum undula	Total Bacteriaceae	Anabaena sp	Aphanocapsa sp	Gloeocapsa conglomerata	Gloeocapsa sp
1/ 5						
1/12		400				
1/19						
1/25			400			
2/ 2			1,600			
2/ 8						
2/15						
2/23		79,344				
3/ 1						
3/ 8						105,792
3/15						1,600
2/23		52,896				3,200
3/29			264,480			3,200
4/ 5		317,376				
4/13						6,400
4/19						
4/26						3,200
5/ 3						
5/10						
5/17	3,200	3,200				
5/24						
5/31			423,168			
6/ 7	105,792	105,792				
6/16			12,800			
6/21			6,400	79,344		
6/28			502,512			
7/ 5			3,200			
7/12			1,904,256	185,136		105,792
7/19			1,692,672			370,272
7/26			1,745,568	528,960	211,584	581,856
8/ 2			1,533,984	634,752	3,200	740,544
8/ 9			2,221,632	1,269,504	3,200	476,064
8/15			2,115,840	317,376		581,856
8/23	105,792	105,792	1,586,880	634,752	12,800	793,440
8/31			1,163,712	317,376		423,168
9/ 6			740,544	12,800		317,376
9/13			423,168	211,584		317,376
9/20						423,168
9/27						740,544
10/ 4				25,600		528,960
10/11	105,792	105,792		211,584		211,584
10/18	105,792	105,792	105,792			211,584
10/26	105,792	105,792	12,800			12,800
11/ 1						[illegible]5,792
11/ 8						[illegible]400
11/15	52,896	52,896				158,688
11/22						79,344
11/30				52,896		
12/ 6						
12/14			3,200			
12/20			52,896			
12/27						52,896

1913	Gomphosphaera aponina	Inactis tinctoria Agardh	Merismopedium glaucum	Microcystis sp	Nostoc sp	Oscillatoria formosa
1/ 5				400		
1/12						19,836
1/19						400
1/25						26,448
2/ 2						1,600

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Gomphosphaera aponina	Inactis tinctoria Agardh	Merismopedium glaucum	Microcystis sp	Nostoc sp	Oscillatoria formosa
2/ 8	1,600					
2/15						
2/23						
3/ 1						
3/ 8	3,200					
3/15	52,896					1,600
3/23						
3/29						3,200
4/ 5						3,200
4/13	3,200			1,600	52,896	
4/19				52,896		
4/26					3,200	
5/ 3						105,792
5/10						
5/17						423,168
5/24						211,584
5/31						
6/ 7						423,168
6/16						528,960
6/21					52,896	79,344
6/28				52,896	3,200	211,584
7/ 5					158,688	52,896
7/12				290,928	583,456	1,600
7/19	3,200			476,064	3,808,512	
7/26	105,792			105,792	581,856	
8/ 2	3,200			158,688	952,128	6,400
8/ 9	3,200			211,584	793,440	6,400
8/15		211,584		3,200	1,114,016	6,400
8/23		634,752		105,792	4,178,784	
8/31		1,692,672	105,792		541,760	
9/ 6		2,115,840			317,376	
9/13		1,269,504	105,792	740,544	740,544	25,600
9/20	211,584	2,115,840		317,376	740,544	12,800
9/27		2,327,424		105,792	317,376	
10/ 4	25,600	634,752		317,376	528,960	105,792
10/11		105,792			12,800	
10/18				211,584	12,800	105,792
10/26				105,792	12,800	
11/ 1	52,896	105,792		6,400	158,688	
11/ 8						6,400
11/15			52,896	6,400		
11/22			1,600	1,600		1,600
11/30				1,600		
12/ 6						1,600
12/14						
12/20						1,600
12/27						1,600

1913	Oscillatoria sp	Oscillatoria tenuis	Phormidium spp	Stigonema sp	Total Schizophyceae	Actinastrum hantzschii
1/ 5						800
1/12					20,236	
1/19					400	
1/25			400		27,248	
2/ 2					3,200	
2/ 8					3,200	
2/15			52,896		52,896	1,600
2/23			52,896		52,896	
3/ 1						
3/ 8					108,992	52,896

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Oscillatoria sp	Oscillatoria tenuis	Phormidium spp	Stigonema sp	Total Schizophyceae	Actinastrum hantzschii
3/15			3,200		59,296	3,200
3/23	52,896				56,096	52,896
3/29	1,600		52,896		325,376	396,720
4/ 5			1,600		4,800	
4/13			3,200		64,096	3,200
4/19					52,896	
4/26	1,600				8,000	12,800
5/ 3			79,344		185,136	
5/10						
5/17				423,168	846,336	
5/24				158,688	370,272	
5/31		105,792		423,168	952,648	105,792
6/ 7				687,648	1,110,816	
6/16	38,400			38,400	618,560	6,400
6/21				105,792	323,776	3,200
6/28				211,584	981,776	79,344
7/ 5				52,896	267,680	3,200
7/12				79,344	3,151,512	185,136
7/19	3,200			158,688	6,512,808	
7/26	3,200				3,864,608	158,688
8/ 2	793,440			3,200	4,829,536	6,400
8/ 9	105,792	3,200		6,400	4,624,352	
8/15	105,792			6,400	4,462,464	19,200
8/23	105,792		158,688		8,211,680	211,584
8/31	211,584		317,376		4,773,440	
9/ 6	105,792				3,609,728	317,376
9/13			317,376	12,800	4,165,288	105,792
9/20					3,821,312	
9/27			105,792		3,596,928	
10/ 4		12,800			2,179,840	25,600
10/11			105,792		647,552	105,792
10/18			105,792		753,344	
10/26					144,192	
11/ 1	211,584		158,688	6,400	825,440	
11/ 8					12,800	
11/15	3,200		105,792		275,680	52,896
11/22					84,144	
11/30		3,200	1,600		59,296	
12/ 6					1,600	
12/14					3,200	
12/20					54,496	
12/27	1,600		1,600		57,696	

1913	Actinastrum hantzschii (large)	Coelastrum microporum	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum
1/ 5			1,200	400		
1/12			800	400		
1/19			26,448	2,400		
1/25			19,836	400	400	
2/ 2			24,000	16,000		
2/ 8			51,200	60,800		
2/15			41,600	16,000	3,200	
2/23			79,344	105,792	1,600	
3/ 1			48,000	19,200		3,200
3/ 8			132,240	19,200	1,600	1,600
3/15			185,136	185,136		
3/23			41,600	54,400	1,600	
3/29			28,800	3,200	9,600	105,792
4/ 5			105,792	12,800	1,600	
4/13			35,200	19,200	1,600	3,200

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Actinastrum hantzschii (large)	Coelastrum microporum	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum
4/19	26,448		79,344	132,240		1,600
4/26	52,896		105,792	16,000		52,896
5/ 3			6,400	1,600	1,600	
5/10						
5/17			12,800	6,400		
5/24						
5/31	105,792					105,792
6/ 7						
6/16				6,400		
6/21	105,792		3,200	32,000		1,600
6/28			9,600	132,240		52,896
7/ 5			1,600	158,688	1,600	
7/12	105,792		3,200	661,200	35,200	3,200
7/19	581,856		25,600	1,322,400	12,800	3,200
7/26	476,064	158,688	6,400	1,798,464	6,400	108,992
8/ 2	158,688		25,600	2,062,944	105,792	3,200
8/ 9	317,376		158,688	899,232		
8/15	528,960	3,200	3,200	1,481,088	32,000	
8/23	1,533,984		158,688	2,697,696	476,064	317,376
8/31	1,586,880	317,376	12,800	2,433,216	25,600	
9/ 6	423,168	105,792	25,600	2,010,048	528,960	
9/31	528,960	317,376	211,584	2,327,424	25,600	
9/20	102,400	317,376	105,792	2,539,008	38,400	211,584
9/27	634,752	105,792	76,800	1,692,672	38,400	211,584
10/ 4	1,163,712		51,200	4,241,680	25,600	634,752
10/11	740,544	105,792	25,600	4,866,432	25,600	528,960
10/18	64,000		12,800	846,336	211,584	
10/26	51,200	105,792	25,600	1,163,712	12,800	
11/ 1	25,600		158,688	793,440	52,896	52,896
11/ 8		52,896	19,200	476,064		
11/15		52,896	6,400	89,600		105,792
11/22	52,896		9,600	79,344		1,600
11/30			6,400	79,344		
12/ 6				19,200		
12/14				52,896		
12/20			6,400	12,800		
12/27				52,896	3,200	

1913	Richteriella botryoides	Scenedesmus obliquus	Scenedesmus quadricauda	Schroederia setigera	Stigeoclonium sp	Total Chlorophyceae
1/ 5			400			2,800
1/12			400			1,600
1/19		400	400			29,648
1/25			400			21,036
2/ 2			105,792			145,792
2/ 8			52,896			164,896
2/15			1,600			64,000
2/23		1,600	12,800			201,136
3/ 1			3,200			73,600
3/ 8			3,200			210,736
3/15	1,600		52,896			427,968
3/23		1,600	132,240			233,040
3/29	1,600	3,200	211,584			762,096
4/ 5		1,600				121,792
4/13			105,792			177,792
4/19		1,600				240,232
4/26	1,600		79,344			321,328
5/ 3					3,200	9,600
5/10						
5/17			3,200			22,400

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Richteriella botryoides	Scenedesmus obliquus	Scenedesmus quadricauda	Schroederia setigera	Stigeoclonium sp	Ttotal Chlorophyceae
5/24		3,200				3,200
5/31		105,792	105,792			528,960
6/ 3		211,584	12,800			224,384
6/16		3,200			6,400	16,000
6/21			3,200			148,992
6/28			3,200			277,270
7/ 5			3,200			168,288
7/12			1,600			998,528
7/19		3,200	211,584			2,160,640
7/26		3,200	317,376			3,034,272
8/ 2		158,688	476,064			2,997,376
8/ 9		3,200	105,792			1,484,288
8/15		6,400	158,688			4,827,840
8/23			581,856			8,251,776
8/31		105,792	1,057,920			5,539,584
9/ 6	952,128	105,792	952,128			5,420,992
9/13	12,800		528,960			4,058,496
9/20			1,057,920			4,371,480
9/27		105,792	423,168			6,288,960
10/ 4		423,168	846,336			7,212,048
10/11		317,376	952,128			7,774,016
10/18		211,584	952,128	105,792		2,397,224
10/26	105,792	105,792	1,057,920			2,628,518
11/ 1	6,400	211,584	581,856			1,889,760
11/ 8		6,400	158,688			713,248
11/15		105,792	158,688	105,792		677,856
11/22		52,896	52,896			249,232
11/30		3,200	105,792			194,736
12/ 6						19,200
12/14		1,600		1,600		56,096
12/20		1,600	1,600			20,400
12/27			52,896			110,792

1913	Asterionella gracillima	Asterionella gracillima (large)	Amphiprora alata	Bacillaria paradoxa	Cocconeis pediculus	Cyclotella spp
1/ 5	4,535,832			39,672		687,648
1/12	945,516			1,200	400	1,031,472
1/19	8,483,196			6,400		1,533,984
1/25	932,292			9,600		515,736
2/ 2	9,283,248		1,600	8,000		740,544
2/ 8	9,918,000	1,600		12,800		1,295,952
2/15	1,904,256			19,200		1,216,608
2/23	2,353,872			9,600		2,136,496
3/ 1	819,888					10,955,872
3/ 8	2,274,528			6,400		6,030,144
3/15	1,005,024			25,600		3,967,200
3/23	1,930,704	52,896		9,600		3,358,896
3/29	2,512,560	105,792		6,400		2,115,840
4/ 5	52,896			581,856		819,888
4/13	555,408	16,000	1,600	41,600		714,096
4/19	687,648	105,792		264,480		1,428,192
4/26	449,616	79,344		185,136		766,992
5/ 3	290,928			211,584		846,336
5/10	2,803,488			105,792		476,064
5/17	158,688	2,164,736			3,200	1,269,504
5/24	211,584	423,168		19,200	3,200	1,110,816
5/31	1,428,192				105,792	2,539,008
6/ 7	1,216,608	3,067,968	105,792	38,400	25,600	2,856,384
6/16	3,173,760	2,909,280		12,800	3,200	1,745,568
6/21	4,549,056	4,443,264		19,200	1,600	608,304

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Asterionella gracillima	Asterionella gracillima (large)	Amphiprora alata	Bacillaria paradoxa	Cocconeis pediculus	Cyclotella spp
6/28	4,866,432	2,962,176		79,344		396,720
7/ 5	608,304	52,896		396,720	1,600	423,168
7/12		79,344		1,248,848		1,269,504
7/19				8,569,152		5,130,912
7/26				3,702,720		10,050,240
8/ 2				21,528,672		10,261,824
8/ 9		3,200		15,392,736		3,596,928
8/15				4,760,640		3,332,448
8/23		3,200		2,062,944		9,045,216
8/31			105,792	4,972,224		14,176,128
9/ 6				846,336	12,800	14,176,128
9/13				4,453,264		14,493,504
9/20				3,067,968		15,868,800
9/27				1,692,672		11,954,496
10/ 4				1,481,088		17,783,116
10/11				528,960		49,300,272
10/18				317,376		42,750,016
10/26				76,800		31,218,700
11/ 1	52,896			158,688		8,569,152
11/ 8	6,400	12,800		105,792		3,702,720
11/15	105,792	12,800		19,200		3,279,552
11/22	1,600	211,584		290,928	1,600	1,533,984
11/30	9,600	52,896		1,322,400		1,246,056
12/ 6	4,443,264			2,909,280	3,200	795,040
12/14	449,616	290,928		2,195,184		1,216,608
12/20	476,064	79,344	1,600	555,408	1,600	1,904,256
12/27	79,344			1,216,608	1,600	1,190,160

1913	Cymatopleura solea	Cymbella affinis	Cymbella cymbiformis	Cymbella sp	Cymbella tumida	Diatom unidentified
1/ 5			800			
1/12			400	400		
1/19						400
1/25	400		800	26,448		
2/ 2	1,600		6,400	79,344		1,600
2/ 8				3,200	3,200	6,400
2/15	6,400		6,400	6,400		3,200
2/23	3,200		3,200	52,896		1,600
3/ 1	3,200		3,200	1,600	6,400	1,600
3/ 8		1,600				
3/15		3,200	6,400			
3/23	3,200	1,600	3,200		3,200	
3/29		79,344	9,600		3,200	1,600
4/ 5	6,400	158,688	3,200		79,344	
4/13	3,200	79,344				52,896
4/19	19,200	79,344	12,800			1,600
4/26	12,800	105,792				
5/ 3	12,800	185,136	3,200		185,136	211,584
5/10	132,240	238,032	19,200		79,344	105,792
5/17	44,800	211,584	12,800		264,480	3,200
5/24	32,000	211,584	12,800		76,800	317,376
5/31	76,800	899,232	12,800		12,800	
6/ 7	51,200	528,960	25,600		64,000	317,376
6/16	19,200	211,584	158,688		32,000	6,400
6/21	19,200	105,792	16,000	3,200	6,400	
6/28	12,800	79,344	3,200		3,200	
7/ 5		6,400			3,200	
7/12	9,600		3,200		6,400	
7/19					3,200	
7/26	12,800				6,400	3,200

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Cymatopleura solea	Cymbella affinis	Cymbella cymbiformis	Cymbella sp	Cymbella tumida	Diatom unidentified
8/ 2		3,200				
8/ 9		3,200	6,400		6,400	
8/15	6,400		6,400		19,200	
8/23						
8/31	12,800				211,584	
9/ 6		105,792				
9/13	12,800		25,600			
9/20	12,800					
9/27	12,800		12,800			
10/ 4		211,584				
10/11		211,584	12,800		12,800	
10/18		105,792			25,600	
10/26			12,800			
11/ 1	6,400		6,400		6,400	
11/ 8	12,800		6,400		19,200	
11/15					52,896	
11/22	1,600		6,400		3,200	
11/30	3,200				32,000	
12/ 6						
12/14		1,600	3,200			
12/20	9,600		3,200		3,200	
12/27		1,600				

1913	Epithemia ocellata	Eunotia sp	Fragilaria capucina	Fragilaria crotonensis	Fragilaria sp	Gomphonema constrictum
1/ 5						
1/12			400			
1/19			2,400			
1/25			39,672			400
2/ 2			9,600			
2/ 8			6,400			
2/15			12,800			
2/23			12,800			
3/ 1	12,800		12,800			
3/ 8			16,000			
3/15	3,200		28,800			
3/23	3,200		132,240	1,600		
3/29	3,200		35,200	6,400		
4/ 5	6,400		22,400	1,600		52,896
4/13	3,200		79,344		1,600	
4/19	3,200		105,792			
4/26			158,688			52,896
5/ 3	3,200		158,688	52,896	158,688	
5/10	6,400		79,344		105,792	79,344
5/17	105,792		19,200			3,200
5/24	6,400		19,200			158,688
5/31	423,168		12,800			317,376
6/ 7	51,200	105,792	51,200		528,960	317,376
6/16	12,800		19,200			158,688
6/21	1,600		22,400			1,600
6/28	11,200		79,344			1,600
7/ 5	3,200		6,400		6,400	
7/12	1,600				1,600	
7/19	6,400		6,400			
7/26	3,200		6,400			
8/ 2	6,400		6,400			3,200
8/ 9	12,800		6,400		3,200	
8/15	6,400		6,400			
8/23					6,400	
8/31	12,800				105,792	

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Epithemia ocellata	Eunotia sp	Fragillaria capucina	Fragillaria crotonensis	Fragillaria sp	Gomphonema constrictum
9/ 6			105,792			
9/13	25,600		105,792	105,792		
9/20						
9/27		12,800				
10/ 4			25,600			
10/11	12,800					
10/18						
10/26		12,800	12,800			
11/ 1	12,800		6,400			
11/ 8	6,400		6,400	52,896		
11/15			12,800			
11/22			1,600	9,600		
11/30	3,200		3,200			
12/ 6			3,200			
12/14						
12/20	9,600					1,600
12/27	52,896	1,600	6,400			

1913	Gomphonema sp	Gyrosigma acuminatum	Gyrosigma kutzingii	Gyrosigma scalproides	Mastogloia braunii	Melosira granulata
1/ 5			2,000			26,448
1/12						19,836
1/19			1,200			30,060
1/25	400		13,224	13,224		85,956
2/ 2			6,400	1,600		608,304
2/ 8			52,896	1,600		502,512
2/15			6,400			634,752
2/23			6,400			1,428,192
3/ 1			3,200			343,824
3/ 8			3,200	52,896		925,680
3/15			79,344			3,438,240
3/23			79,344		6,400	1,877,808
3/29	1,600		132,240		3,200	1,533,984
4/ 5		79,344	79,344	52,896		396,720
4/13	1,600	3,200	25,600	3,200		3,808,512
4/19	105,792	105,792	158,688			7,696,368
4/26			4,800	1,600		6,056,592
5/ 3			158,688			1,243,056
5/10		1,600	79,344	52,896		1,586,880
5/17			211,584	105,792		3,491,136
5/24		3,200	158,688	3,200		2,274,528
5/31			83,200			4,866,432
6/ 7			38,400			4,654,848
6/16			211,584			3,279,552
6/21			12,800			8,198,880
6/28	1,600		12,800	3,200		19,016,112
7/ 5			132,240			11,372,640
7/12			105,792			19,994,688
7/19			19,200			27,294,336
7/26			264,480	12,800		26,871,168
8/ 2			264,480	476,064		65,273,664
8/ 9	6,400		264,480	846,336		61,465,152
8/15			317,376			74,636,256
8/23		105,792	370,272			169,478,784
8/31		423,168	423,168			141,443,904
9/ 6			423,168			180,057,984
9/13			317,376			101,242,944
9/20		105,792	105,792			98,809,728
9/27		25,600	25,600			55,646,592

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Gomphonema sp	Gyrosigma acuminatum	Gyrosigma kützingii	Gyrosigma scalproides	Mastogloia braunii	Melosira granulata
10/ 4	105,792		105,792			45,914,928
10/11	105,792	423,168	105,792			73,852,864
10/18			211,584			25,505,920
10/26						12,483,456
11/ 1			12,800			12,007,392
11/ 8		12,800	105,792			4,178,784
11/15		6,400				1,481,088
11/22	1,600		52,896			3,041,520
11/30	1,600		6,400			14,176,128
12/ 6			1,600			2,142,288
12/14			79,344			608,304
12/20			3,200			846,336
12/27	1,600		1,600			661,200

1913	Melosira granulata A (small)	Melosira varians	Navicula affinis	Navicula alpestris	Navicula bacillum	Navicula didyma
1/ 5		52,896				
1/12		4,800				
1/19		39,672	19,836			
1/25		79,344				
2/ 2		79,344				
2/ 8		44,800				3,200
2/15		185,136				
2/23		105,792				
3/ 1		158,688				
3/ 8		105,792		264,480		
3/15		449,616	1,600	79,344		
3/23		264,480	1,600	105,792		
3/29	5,368,944	290,928	105,792	52,896		3,200
4/ 5	1,600	343,824	6,400	52,896		
4/13	1,243,056	185,136	1,600	1,600		52,896
4/19	290,928	528,960		79,344	238,032	52,896
4/26	238,032	581,856	3,200	79,344	185,136	
5/ 3	52,896	502,512	52,896	79,344	185,136	
5/10	185,136	634,752	52,896	185,136	343,824	
5/17		1,163,712		3,200	793,440	
5/24	211,584	634,752		264,480	634,752	
5/31	634,752	1,216,608		899,232	1,005,024	
6/ 7		793,440		317,376	1,322,400	
6/16		317,376		317,376	581,856	
6/21		238,032	3,200	3,200	211,584	1,600
6/28		449,616	79,344	3,200	79,344	1,600
7/ 5		132,240		52,896	79,344	
7/12		238,032		52,896	52,896	
7/19		105,792			105,792	
7/26		158,688		3,200		
8/ 2		158,688			105,792	
8/ 9		158,688			105,792	3,200
8/15		12,800		3,200	158,688	
8/23		105,792		264,480		3,200
8/31					105,792	211,584
9/ 6		211,584		317,376	317,376	
9/13		105,792		12,800	740,544	
9/20		105,792		105,792	211,584	
9/27					105,792	
10/ 4				211,584	105,792	
10/11		211,584			211,584	
10/18					211,584	
10/26					317,376	

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Melosira granulata A (small)	Melosira varians	Navicula affinis	Navicula alpestris	Navicula bacillum	Navicula didyma
11/ 1		211,584		158,688		
11/ 8		105,792			52,896	52,896
11/15		12,800				
11/22		19,200				
11/30		52,896		3,200		
12/ 6		79,344		1,600	52,896	
12/14		52,896			1,600	
12/20		12,800		6,400	52,896	
12/27		423,168		3,200	132,240	

1913	Navicula dubia	Navicula gracilis	Navicula sp	Navicula viridis	Nitzschia acicularis	Nitzschia angularis
1/ 5			59,908	400	39,672	
1/12			800	800	39,672	
1/19				13,224	19,836	
1/25		72,732	13,224	1,200	59,508	400
2/ 2		158,688		3,200	185,136	8,000
2/ 8		185,136	3,200	3,200	52,896	6,400
2/15		105,792			105,792	3,200
2/23		105,792	1,600	1,600	52,896	6,400
3/ 1		132,240	80,944	6,400	52,896	3,200
3/ 8		1,600	105,792	3,200	133,840	6,400
3/15		423,168	1,600	6,400	105,792	9,600
3/23		343,824	1,600	6,400	1,600	3,200
3/29		264,480	4,800	6,400	264,480	3,200
4/ 5		423,168	3,200	19,200	132,240	132,240
4/13		317,376	105,792	6,400	80,944	
4/19		793,440		3,200	105,792	79,344
4/26		581,856	3,200	3,200	608,304	3,200
5/ 3		290,928		132,240	158,688	105,792
5/10		661,200	79,344	185,136	52,896	79,344
5/17		1,745,568	16,000	38,400	105,792	211,584
5/24		1,586,880	161,888	158,688	264,480	32,000
5/31		1,110,816	105,792	211,584	1,005,024	25,600
6/ 7		1,216,608	105,792	96,000	1,216,608	64,000
6/16	3,200	634,752		19,200	581,856	19,200
6/21		132 240		3,200	528,960	9,600
6/28		185,136		25,600	581,856	12,800
7/ 5		264,480	4,800	3,200	370,272	
7/12		528,960	3,200	6,400	264,480	3,200
7/19		423,168			740,544	
7/26		846,336	6,400		423,168	
8/ 2	12,800	793,440		19,200	476,064	
8/ 9		1,639,776		12,800	158,688	105,792
8/15		2,750,592		3,200	317,376	
8/23	158,688	3,649,824			370,272	
8/31		3,596,928		105,792	846,336	
9/ 6		2,644,800			1,057,920	
9/13		1,798,464		25,600	634,752	
9/20		1,269,504			317,376	12,800
9/27		846,336		211,584	317,376	
10/ 4		740,544		25,600	846,336	
10/11		1,481,088		12,800	634,752	
10/18		423,168	105,792		528,960	
10/26	105,792	423,168		25,600	423,168	
11/ 1		52,896		12,800	264,480	
11/ 8		211,584		6,400	105,792	
11/15		52,896		6,400	370,272	
11/22		185,136			52,896	

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Navicula dubia	Navicula gracilis	Navicula sp	Navicula viridis	Nitzschia acicularis	Nitzschia angularis
11/30		476,064		3,200	52,896	
12/ 6		396,720			79,344	
12/14		132,240			158,688	
12/20		185,136			1,600	
12/27		264,480	6,400	3,200	52,896	

1913	Nitzschia sigma	Nitzschia sigmoidea	Nitzschia sp	Nitzschia vermicularis	Pleurostauron parvulum	Rhopalodia gibba
1/ 5				400	238,032	
1/12					145,464	
1/19			79,344		238,032	
1/25		400	23,436		522,348	
2/ 2				4,800	396,720	
2/ 8	1,600				476,064	
2/15		3,200		12,800	423,168	
2/23		1,600			238,032	
3/ 1		52,896			264,480	
3/ 8		1,600		1,600	502,512	
3/15				3,200	317,376	
3/23		3,200	1,600		476,064	
3/29		79,344		9,600	581,856	
4/ 5		3,200	52,896		343,824	
4/13		79,344	52,896		502,512	
4/19			158,688		132,240	
4/26	6,400	52,896			661,200	
5/ 3	3,200	9,600	343,824		449,616	
5/10	52,896	52,896	52,896		132,240	
5/17	211,584	12,800	108,992	6,400	687,648	
5/24	3,200	6,400	423,168		793,440	
5/31	317,376	105,792	899,232		1,216,608	
6/ 7	317,376	105,792	317,376		793,440	
6/16	6,400	12,800	214,784	6,400	211,584	6,400
6/21	3,200	3,200	52,896		79,344	3,200
6/28	3,200	6,400	52,896		1,600	
7/ 5		6,400	1,600	3,200	1,600	
7/12			185,136	1,600	132,240	
7/19			158,688		3,200	
7/26			3,200	6,400	264,480	
8/ 2	6,400		370,272	6,400	105,792	
8/ 9	105,792		476,064			
8/15	105,792		370,272	6,400	105,792	
8/23	211,584		2,539,008	105,792		
8/31	105,792			25,600	105,792	
9/ 6	105,792			423,168		
9/13	105,792			317,376		
9/20	105,792			211,584		
9/27	105,792			105,792	317,376	
10/ 4	317,376			12,800	211,584	
10/11				12,800	317,376	
10/18	12,800		12,800	51,200	105,792	
10/26					12,800	
11/ 1				12,800	52,896	
11/ 8				6,400	2,896	
11/15				6,400	52,896	
11/22	3,200				158,688	
11/30	3,200	1,600			132,240	
12/ 6	1,600				52,896	
12/14	3,200				238,032	
12/20	3,200				158,688	
12/27	3,200				211,584	

TABLE 2 —ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Stauroneis phoenicenteron	Surirella sp	Synedra radians	Synedra ulna	Tabellaria sp	Total Bacillariaceae
1/ 5		800		125,6 8	400	5,809,536
1/12	400	400		59,508		2,251,768
1/19		34,260		469,452		10,974,996
1/25	400	73,108		178,524		2,663,576
2/ 2		120,192		290,928		11,996,848
2/ 8		83,200		264,480		12,933,536
2/15	3,200	118,400		238,032		5,016,736
2/23		67,200		264,480		6,856,748
3/ 1		264,480		185,136		13,325,744
3/ 8		211,584		370,272		11,019,120
3/15		264,480		581,856		10,801,040
3/23		211,584		290,928		9,134,064
3/29		264,480		370,272		14,115,040
4/ 5		555,408		661,200		5,260,608
4/13		185,136		687,648		8,892,336
4/19		555,408		502,512		14,298,672
4/26		211,584		211,584		11,305,248
5/ 3	3,200	1,084,368		502,512		7,678,572
5/10	3,200	978,576		819,888		10,505,408
5/17	211,584	1,798,464		899,232		16,196,288
5/24	12,800	634,752		740,544		11,764,928
5/31		793,440		687,648		21,702,976
6/ 7		1,428,192		687,648		22,407,344
6/16		793,440		423,168		16,107,296
6/21		290,928		211,584		19,785,264
6/28	6,400	528,960		290,928	6,400	29,834,352
7/ 5	3,200	158,688		79,344		14,174,332
7/12		581,856		158,688		25,030,060
7/19		423,168	476,064	105,792	3,200	43,575,008
7/26	3,200	952,128	370,272	211,584		44,644,352
8/ 2	3,200	2,539,008	370,272	317,376	3,200	102,741,536
8/ 9		4,707,744	105,792	317,376		90,369,664
8/15	12,800	1,745,568	370,272	105,792		90,117,192
8/23		2,010,048	476,064	211,584		193,347,650
8/31		2,327,424	1,057,920	4,866,432		178,086,636
9/ 6		1,269,504	1,057,920	2,750,592		211,605,800
9/13		1,481,088	211,584	6,463,312		132,958,752
9/20	12,800	846,336	317,376	1,904,256		123,920,832
9/27		1,163,712	317,376	1,269,504		74,461,376
10/ 4		925,128	423,168	2,433,216		72,648,572
10/11		1,269,504	634,752	2,327,424		132,110,672
10/18		634,752	105,792	846,336		71,980,864
10/26	12,800	1,163,712	317,376	634,752		47,266,700
11 1		423,168	423,168	476,064		22,980,768
11/ 8	6,400	952,128	52,896	158,688		10,205,536
11/15		83,200	52,896	105,792		5,766,976
11/22		423,168	185,136	158,688		6,451,616
11/30		317,376	1,600	158,688		18,058,240
12/ 6		185,136		317,376		11,466,384
12/14	3,200	238,032	132,240	185,136		6,252,552
12/20		264,480	52,896	132,240		4,821,440
12/27		528,960	1,600	264,480		5,190,960

1913	Algae unidentified	Closterium acerosum	Closterium acuminatum	Closterium rostratum	Mougeotia sp	Spirogyra proteota
1/ 5					800	
1/12						2,800
1/19					400	.
1/25		1,600				.
2/ 2		1,600				...

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Algae unidentified	Closterium acerosum	Closterium acuminatum	Closterium rostratum	Mougeotia sp	Spirogyra protecta
2/ 8		3,200				
2/15		6,400				
2/23	1,600					3,200
3/ 1					1,600	
3/ 8		3,200				
3/15						
3/23				1,600		3,200
3/29						
4/ 5		6,400			3,200	238,032
4/13						
4/19		3,200				
4/26						
5/ 3					3,200	
5/10		3,200				
5/17						6,400
5/24		6,400				
5/31		12,800				
6/ 7						
6/16						
6/21		3,200				
6/28		12,800	3,200			
7/ 5		3,200			3,200	
7/12			6,400		555,408	
7/19		6,400			370,272	
7/26		12,800			476,064	
8/ 2		25,600	12,800		370,272	
8/ 9		38,400			581,856	
8/15				3,200	2,591,904	
8/23		19,200			2,380,320	
8/31		12,800		211,584	4,347,472	
9/ 6		64,000			211,584	
9/13		38,400			952,128	
9/20		12,800		105,792	317,376	
9/27		25,600				
10/ 4				105,792		
10/11		25,600			317,376	
10/18						
10/26						
11/ 1		6,400				
11/ 8						
11/15					158,688	
11/22		3,200			1,600	
11/30		3,200		1,600		
12/ 6		3,200				
12/14		3,200				
12/20				3,200		
12/27		1,600			1,600	79,344

1913	Spirogyra sp	Staurastrum A	Staurastrum sp	Total Conjugatae	Total Chlorophyll bearing	Total Algae
1/ 5	800			1,600	5,814,336	5,813,936
1/12				1,800	2,278,204	2,275,804
1/19	1,200			3,200	13,272,348	11,008,244
1/25	19,836			21,436	3,660,576	2,733,296
2/ 2				1,600	13,769,920	12,047,440
2/ 8				23,036	16,125,644	13,124,668
2/15		6,400		12,800	8,114,160	5,146,432
2/23		3,200		8,000	9,711,436	7,198,124
3/ 1				1,600	14,171,888	13,400,944
3/ 8		6,400		9,600	11,555,584	11,348,448

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Spirogyra sp	Staurastrum A	Staurastrum sp	Total Conjugatae	Total Chlorophyll bearing	Total Algae
3/15	1,600			3,200	11,562,384	11,291,504
3/23	3,200			11,200	10,227,840	9,487,296
3/29		3,200		6,400	16,907,984	15,208,872
4/ 5	3,200	1,600		252,432	5,806,320	5,957,008
4/13					9,506,848	9,134,224
4/19				3,200	14,702,392	14,595,000
4/26			1,600		11,812,464	11,634,576
5/ 3				6,400	8,145,788	7,879,708
5/10				3,200	10,720,192	10,508,608
5/17				6,400	17,202,816	17,074,624
5/24			3,200	9,600	12,260,192	12,148,000
5/31				12,800	24,202,408	23,197,384
6/ 7					24,771,432	23,848,336
6/16	6,400			12,800	17,318,816	16,754,656
6/21				6,400	20,548,016	20,264,432
6/28		1,600		17,600	31,173,494	31,110,998
7/ 5		52,896	1,600	60,896	15,385,292	14,671,196
7/12		105,792		667,600	30,992,964	29,847,700
7/19		12,800	3,200	392,672	58,626,280	52,641,128
7/26		158,688	3,200	653,952	60,004,896	52,222,784
8/ 2		6,400	423,168	838,240	114,102,688	111,419,488
8/ 9		476,064	105,792	1,205,292	100,712,962	97,689,996
8/15		211,584	317,376	532,160	101,975,404	99,939,656
8/23		423,168	423,168	865,536	214,321,570	210,788,834
8/31		317,376		5,206,608	196,911,420	193,606,268
9/ 6	12,800	211,584	317,376	817,344	226,118,120	221,453,864
9/13		740,544	105,792	1,836,864	148,511,000	143,032,200
9/20		1,057,920	105,792	1,599,680	137,149,848	133,713,304
9/27		740,544		766,144	90,015,440	85,113,408
10/ 4		211,584	105,792	423,068	90,224,744	82,463,528
10/11		211,584	105,792	660,350	147,152,542	141,298,382
10/18		105,792		105,792	84,014,960	75,340,016
10/26					58,621,362	50,145,202
11/ 1				6,400	29,859,648	25,702,368
11/ 8					14,369,824	10,931,584
11/15				62,688	11,064,384	6,836,096
11/22		1,600		6,400	13,861,008	6,791,392
11/30		1,600		9,600	22,768,336	18,321,872
12/ 6				3,200	16,767,936	11,490,384
12/14		1,600		4,800	9,313,272	6,316,648
12/20				5,200	7,212,112	4,901,536
12/27				80,944	6,237,032	5,440,392

1913	Ceratium hirundinella	Cercomonas crassicauda	Chlamydomonas sp	Chromulina sp	Dinobryon sertularia	Eudorina elegans
1/ 5						400
1/12						2,800
1/19				2,228,244		2,000
1/25				826,500		800
2/ 2				1,428,192		30,800
2/ 8				2,962,176		22,400
2/15				2,856,384		19,200
2/23				2,300,976		158,688
3/ 1				740,544		22,400
3/ 8				52,896		28,800
3/15				52,896	1,600	
3/23				290,928		158,688
3/29				978,576	3,200	502,512
4/ 5				105,792		6,400
4/13				158,688		25,600

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Ceratium hirundinella	Cercomonas crassicauda	Chlamydomonas sp	Chromulina sp	Dinobryon sertularia	Eudorina elegans
4/19						3,200
4/26				52,896		16,000
5/ 3						
5/10					158,688	
5/17				3,200	12,800	6,400
5/24			105,792			3,200
5/31						
6/ 7	12,800			105,792	12,800	51,200
6/16				264,480	158,688	25,600
6/21				158,688	3,200	64,000
6/28						3,200
7/ 5				555,408		105,792
7/12	1,600			555,408		502,512
7/19				5,818,560		44,800
7/26		3,200		6,823,584		317,376
8/ 2			3,200	2,010,048		105,792
8/ 9	6,400			1,057,920		1,481,088
8/15				1,481,088		6,400
8/23			3,200	3,067,968		19,200
8/31	12,800		317,376	2,644,800		
9/ 6				3,808,512		211,584
9/13	25,600			4,241,680		38,400
9/20		105,792		2,644,800		38,400
9/27			105,792	4,347,472		12,800
10/ 4				7,088,064		25,600
10/11				5,183,808		25,600
10/18				7,722,816		
10/26				8,251,776		105,792
11/ 1				3,914,304	6,400	105,792
11/ 8				2,962,176	105,792	52,896
11/15				3,914,304		52,896
11/22				6,717,792	132,240	3,200
11/30				4,231,680		52,896
12/ 6				5,183,808	1,600	12,800
12/14				2,988,624		3,200
12/20				2,142,288		3,200
12/27				793,440		

1913	Euglena viridis	Flagellate unidentified	Hemidinium nasutum	Pandorina morum	Peridinium cinctum	Phacus pleuronectes
1/ 5						
1/12						
1/19				400		
1/25				800		
2/ 2				4,800		
2/ 8				3,200		
2/15				12,800		
2/23		1,600		19,200		
3/ 1		3,200		3,200		
3/ 8				1,600		
3/15				3,200		
3/23				79,344		
3/29				79,344		
4/ 5						
4/13				3,200		
4/19				1,600		
4/26		3,200				
5/ 3		1,600				
5/10						
5/17		3,200				

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Euglena viridis	Flagellate unidentified	Hemidinium nasutum	Pandorina morum	Peridinium cinctum	Phacus pleuronectes
5/24						
5/31						
6/ 7	211,584			105,792		
6/16	3,200			6,400		
6/21				1,600		
6/28						
7/ 5					52,896	
7/12	1,600			79,344		
7/19				105,792		
7/26	105,792			3,200	3,200	
8/ 2	3,200			6,400		
8/ 9	3,200		105,792	105,792		
8/15	3,200		211,584		3,200	
8/23	6,400		105,792			
8/31						
9/ 6				12,800		
9/13			211,584			
9/20			105,792	105,792		
9/27						
10/ 4	105,792				105,792	
10/11			211,584			
10/18	105,792		528,960			
10/26						
11/ 1				6,400	52,896	
11/ 8						52,896
11/15				6,400	52,896	
11/22				52,896		1,600
11/30				52,896		
12/ 6						
12/14				3,200		
12/20	52,896			6,400		
12/27						

1913	Platydorina caudata	Pleodorina californica	Pleodorina illinoisensis	Pteromonas sp	Trachelomonas euchlora	Trachelomonas volgensis
1/ 5						
1/12						
1/19						
1/25					66,120	
2/ 2						
2/ 8					1,600	
2/15						
2/23					52,896	
3/ 1						
3/ 8					132,240	
3/15					79,344	
3/23					79,344	
3/29					132,240	
4/ 5					52,896	
4/13					79,344	
4/19					52,896	
4/26						
5/ 3					132,240	
5/10					52,896	
5/17						
5/24					3,200	
5/31						
6/ 7					211,584	
6/16						
6/21		3,200				

TABLE 2—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Cotinued*)

1913	Platydorina caudata	Pleodorina californica	Pleodorina illinoisensis	Pteromonas sp	Trachelomonas euchlora	Trachelomonas volgensis
6/28						
7/ 5						
7/12		3,200				
7/19		12,800				
7/26	6,400	158,688		158,688		
8/ 2	19,200	158,688				
8/ 9	38,400	105,792	6,400			
8/15	12,800	158,688				
8/23	12,800	105,792				
8/31	12,800	211,584				
9/ 6		89,600				105,792
9/13	64,000	51,200				
9/20		12,800				105,792
9/27	12,800					
10/ 4		12,800				
10/11				105,792		
10/18						105,792
10/26		12,800				
11/ 1	6,400	6,400				
11/ 8			6,400			
11/15						
11/22					1,600	1,600
11/30						105,792
12/ 6						
12/14						
12/20						
12/27				1,600		

1913	Trachelomonas volvocina	Volvox aureus	Total Mastigophora	Amoeba proteus	Amoeba radiosa	Arcella vulgaris
1/ 5			400			
1/12			2,800			
1/19	33,060		2,264,104			
1/25	33,060		927,280			
2/ 2	79,344		1,622,480			
2/ 8	1,600		3,000,976			
2/15	79,344		3,028,528			
2/23	52,896		2,592,656			
3/ 1	1,600		770,944			
3/ 8			217,136			
3/15	132,240		270,880			
3/23	185,136		793,440			
3/29	1,600		1,699,072	3,200		
4/ 5			166,688	3,200		
4/13	105,792		372,624			1,600
4/19	52,896		107,392			
4/26	105,792		177,888		52,896	3,200
5/ 3			266,080			
5/10	1,600		211,584			
5/17	105,792		131,392		3,200	
5/24			112,192			
5/31	317,376		1,005,024			
6/ 7	317,376		1,028,888			12,800
6/16	105,792		564,160			
6/21	52,896		283,584			
6/28	52,896		62,496			3,200
7/ 5			714,096			
7/12	1,600		1,145,264			
7/19	3,200		5,985,152			
7/26	211,584	25,600	7,807,712			

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Trachelomonas volvocina	Volvox aureus	Total Mastigophora	Amoeba proteus	Amoeba radiosa	Arcella vulgaris
8/ 2		12,800	2,696,000			
8/ 9		6,400	3 029,366			
8/15	158,688		2,035,748	3,200		
8/23	264,480	6,400	3,644,928	528,960		
8/31	423,168		3,622,528			
9/ 6	317,376		4,664,256	211,584		
9/13	740,544	12,800	5,491,600			
9/20	317,376		3,436,544		211,584	
9/27	423,168		4,902,032			
10/ 4	528,960		7,761,216			
10/11	423,168		5,959,952		105,792	
10/18	317,376		8,780,736			
10/26	211,584		8,581,952		12 800	
11/ 1	158,688		4,157,280		52,896	
11/ 8	211,584		3,438,240			
11/15	105,792		4,281,184		158,688	
11/22	158,688		7,096,616	3,200		
11/30	52,896		4,446,464			
12/ 6	79,344		5,277,552			
12/14	1,600		2,996,624			
12/20	52,896		2,310,576		1,600	
12/27	1,600		796,640			

1913	Cyphoderia ampulla	Difflugia corona	Difflugia pyriformis	Hyalodiscus sp	Microgromia socialis	Total Rhizopoda
1/ 5						
1/12						
1/19						
1/25			400			400
2/ 2			1,600			1,600
2/ 8			1,600			1,600
2/15			12,800			12,800
2/23			19,200		79,344	98,544
3/ 1			3,200			4,800
3/ 8			9,600			12,800
3/15						
3/23						1.600
3/29						3,200
4/ 5			6,400			16,000
4/13			6,400			8,000
4/19	52,896		79,344			132,240
4/26			32,000			88,096
5/ 3						
5/10						
5/17			19,200			22,400
5/24			6,400			6,400
5/31			634,752			634,752
6/ 7	12,800		793,440			104,944
6/16			158,688			158,688
6/21			211,584			211,584
6/28			185,136			189,936
7/ 5			158,688			158,688
7/12	3,200		132,240		1,600	146,640
7/19						3,200
7/26			12,800		158,688	171,488
8/ 2			6,400		158,688	168,288
8/ 9						3,200
8/15		6,400	19,200	3,200	105,792	131,392
8/23					158,688	1,189,312
8/31		12,800	105,792	317,376	211,584	647,552

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Cyphoderia ampulla	Difflugia corona	Difflugia pyriformis	Hyalodiscus sp	Microgromia socialis	Total Rhizopoda
9/ 6	12,800		25,600		317,376	567,360
9/13					211,584	211,584
9/20		12,800		105,792		330,176
9/27		12,800		12,800	105,792	131,392
10/ 4					846,336	846,336
10/11	12,800			105,792	105,792	330,176
10/18					211,584	211,584
10/26				105,792	211,584	330,176
11/ 1				52,896	52,896	158,688
11/ 8			52,896	105,792		211,584
11/15						158,688
11/22			3,200			6,400
11/30						
12/ 6			1,600			1,600
12/14		3,200				3,200
12/20			1,600			3,200
12/27	1,600	9,600				11,200

1913	Actinophrys sol	Heterophrys fockei	Heterophrys sp	Nuclearia simplex	Pinaciophora fluviatilis	Raphidiophrys elegans
1/ 5						
1/12						
1/19						
1/25						
2/ 2						
2/ 8						
2/15						
2/23						
3/ 1						
3/ 8						
3/15						
3/23			1,600	1,600		
3/29						3,200
4/ 5						
4/13						
4/19						
4/26						
5/ 3						
5/10						
5/17						
5/24						
5/31						
6/ 7						
6/16						
6/21						52,896
6/28						
7/ 5						
7/12				9,600	1,600	1,600
7/19			158,688	3,200		476,064
7/26						
8/ 2		211,584		3,200		211,584
8/ 9	3,200	317,376				105,792
8/15	6,400	211,584	105,792			105,792
8/23		317,376				476,064
8/31						211,584
9/ 6						634,752
9/13		38,400				105,792
9/20	12,800	1,269,504				105,792
9/27	105,792	1,481,088				

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Actinophrys sol	Heterophrys fockei	Heterophrys sp	Nuclearia simplex	Pinaciophora fluviatilis	Raphidiophrys elegans
10/ 4		2,962,176				
10/11		317,376			1,269,504	
10/18		12,800			423,168	
10/26	12,800	105,792			317,376	
11/ 1						105,792
11/ 8						52,896
11/15					52,896	1,481,088
11/22					1,600	
11/30					1,600	1,600
12/ 6						
12/14						
12/20						
12/27						

1913	Total Heliozoa	Chilodon sp	Ciliate unidentified	Coleps hirtus	Cyclidium sp	Epistylis sp
1/ 5						
1/12						
1/19			400			
1/25			400			
2/ 2			1,600			
2/ 8			6,400			
2/15			1,600			
2/23			6,400			
3/ 1			79,344			
3/ 8						3,200
3/15			1,600			
3/23	1,600		1,600			
3/29	3,200					
4/ 5			185,136			3,200
4/13						
4/19						
4/26						
5/ 3			105,792			
5/10						
5/17						
5/24						
5/31						
6/ 7						12,800
6/16						
6/21	52,896					
6/28						
7/ 5						
7/12	3,200					
7/19	476,064					
7/26						
8/ 2	423,168					
8/ 9	426,368	105,792				
8/15	429,568				105,792	
8/23	317,376				3,200	
8/31	211,584			105,792	105,792	
9/ 6	634,752				105,792	
9/13	144,192				105,792	
9/20	1,388,096					
9/27	1,586,880					
10/ 4	2,962,176					
10/11	1,586,880				105,792	
10/18	435,968					
10/26	435,968					

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Total Heliozoa	Chilodon sp	Ciliate unidentified	Coleps hirtus	Cyclidium sp	Epistylis sp
11/ 1	105,792					
11/ 8	52,896	12,800		52,896		
11/15	1,533,984					
11/22	1,600					
11/30	3,200					
12/ 6						
12/14						
12/20						
12/27						

1913	Euplotes harpa	Euplotes patella	Holophrya sp	Paramecium aurelia	Paramecium bursaria	Prorodon sp
1/ 5						
1/12						
1/19	400					
1/25	400					
2/ 2						
2/ 8						
2/15	6,400					
2 23	12,800	3,200				1,600
3/ 1	3,200	3,200		3,200		3,200
3/ 8						
3/15	3,200		105,792			
3/23	16,000		79,344			
3/29	3,200		3,200			
4/ 5			105,792			
4/13			1,600			
4/19			132,240		3,200	6,400
4/26			1,600			
5/ 3			1,600		3,200	
5/10						
5/17			3,200			
5/24			264,480			
5/31			12,800			
6/ 7			211,584			
6/16			105,792			
6/21						
6/28						1,600
7/ 5						
7/12						
7/19			211,584			
7/26			317,376			
8/ 2			158,688			
6/ 9			528,960			
8/15			158,688			
8/23						3,200
8/31			211,584			
9/ 6						
9/13			105,792			
9/20			634,752		105,792	
9/27			105,792			
10/ 4			211,584			
10/11			105,792			
10/18						
10/26						12,800
11/ 1	6,400		52,896	19,200		
11/ 8			52,896			
11/15	264,480			51,200	105,792	6,400
11/22	9,600		105,792		3,200	

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Euplotes harpa	Euplotes patella	Holophrya sp	Paramecium aurelia	Paramecium bursaria	Prorodon sp
11/30						
12/ 6	52,896		1,600			
12/14	3,200					
12/20			1,600			
12/27						

1913	Stentor coeruleus	Stentor niger	Tintinnidium fluviatile	Vorticella longifilum	Vorticella sp	Total Ciliata
1/ 5						
1/12						
1/19						800
1/25						800
2/ 2		1,600				4,800
2/ 8						297,328
2/15						9,600
2/23		3,200				162,640
3/ 1		3,200				148,240
3/ 8		3,200				558,708
3/15						110,592
3/23		3,200		6,400		529,712
3/29				3,200		429,568
4/ 5	3,200			3,200	3,200	303,728
4/13					79,344	213,184
4/19						379,872
4/26		3,200				216,384
5/ 3		6,400			132,240	249,232
5/10		6,400				6,400
5/17					158,688	373,472
5/24		3,200			264,480	532,160
5/31					793,440	806,240
6/ 7					793,440	1,017,824
6/16					158,688	267,680
6/21					105,792	105,792
6/28					3,200	4,800
7/ 5					211,584	211,584
7/12					211,584	211,584
7/19					1,057,920	1,269,504
7/26					528 960	846,336
8/ 2			,200		1,057,920	1,219,808
8/ 9					846,336	1,481 088
8/15					793,440	1,057,920
8/23					370,272	383,072
8/31					1,692,672	2,115,840
9/ 6					317,376	317,376
9/13					952,128	1,163,712
9/20					423,168	1,163,712
9/27					846,336	952,128
10/ 4				105,792	528,960	846,336
10/11					423,168	634,752
10/18			105,792		528,960	634,752
10/26				12,800	317,376	342,976
11/ 1			52,896		423,168	554,560
11/ 8					52,896	330,176
11/15					52,896	487,168
11/22			3,200			121,792
11/30					1,600	1,600
12/ 6	3,200	1,600			1,600	60,896
12/14			6,400			9,600
12/20				3,200	132,240	137,040
12/27		3,200	3,200			6,400

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Acineta sp	Podophrya sp	Sphaerophrya sp	Total Suctoria	Total Protozoa without Mastigophora	Total Protozoa with Mastigophora
1/ 5						400
1/12						2,800
1/19					800	2,264,904
1/25					1,200	928,480
2/ 2					6,400	1,628,880
2/ 8					298,928	3,299,904
2/15					22,400	3,050,928
2/23					261,184	2,853,840
3/ 1					153,040	923,984
3/ 8					571,508	788 644
3/15					110,592	381,472
3/23					532,912	1,326,352
3/29					435,968	2,135,040
4/ 5					319,728	486,416
4/13					221,184	593,808
4/19					512,112	619,504
4/26	3,200			3,200	307,680	485,568
5/ 3					249,232	515,312
5/10					6,400	217,984
5/17					395,872	527,264
5/24					538,560	651,752
5/31					1,440,992	2,446,016
6/ 7					1,122,768	2,151,656
6/16					426,368	990,528
6/21					370,272	653,856
6/28					194,736	257,232
7/ 5					370,272	1,084,368
7/12	6,400			6,400	367,824	1,513,088
7/19					1,907,456	7,892,608
7/26					1,017,824	8,825,536
8/ 2					1,811,264	4,507,264
8/ 9			19,200	19,200	1,929,856	4,959,222
8/15	105,792			105,792	1,724,672	3,760,420
8/23					1,889,760	5,534,688
8/31					2,974,976	6,597,504
9/ 6					1,519,488	6,183,744
9/13					1,519,488	7,011,088
9/20			25,600	25,600	2,907,584	6,344,128
9/27			12,800	12,800	2,683,200	7,585,232
10/ 4	105,792		38,400	144,192	4,799,040	12,560,256
10/11					2,551,808	8,511,760
10/18			25,600	25,600	1,307,904	10,088,640
10/26	105,792			105,792	1,214,912	9,796,864
11/ 1					819,040	4,976,320
11/ 8					594,650	4,032,896
11/15					2,179,840	6,461,024
11/22			3,200	3,200	132,992	7,202,608
11/30		3,200	3,200	6,400	11,200	4,457,664
12/ 6		3,200	1,600	4,800	67,296	5,344,848
12/14	3,200			3,200	16,000	3,012,624
12/20					140,240	2,450,816
12/27		1,600		1,600	19,200	815,840

1913	Collotheca egg, attached	Collotheca pelagica	Collotheca sp	Total Rhizota	Rotaria neptunia	Rotaria rotatoria
1/ 5						2,000
1/12						4,400
1/19					400	52,896
1/25				400	2,400	26,448
2/ 2						107,392

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Collotheca egg, attached	Collotheca pelagica	Collotheca sp	Total Rhizota	Rotaria neptunia	Rotaria rotatoria
2/ 8						57,600
2/ 5						12,800
2/23						79,344
3/ 1						32,000
3/ 8						80,000
3/15						79,344
3/23					3,200	185,136
3/29						22,400
4/ 5						9,600
4/13						
4/19						
4/26						
5/ 3						
5/10						
5/17						6,400
5/24						6,400
5/31						
6/ 7						
6/16						
6/21						
6/28						3,200
7/ 5						
7/12					3,200	
7/19						
7/26						6,400
8/ 2					6,400	12,800
8/ 9			6,400			
8/15	83,200	158,688	6,400	248,288	12,800	19,200
8/23	83,200	317,376		400,576		6,400
8/31				12,800		12,800
9/ 6						
9/13	12,800	38,400		51,200		
9/20		51,200		51,200	12,800	
9/27	12,800	38,400		51,200		
10/ 4	128,300	140,800		268,800	25,600	25,600
10/11	7[illegible],800	115,200		192,000	25,600	
10/18	211,584	51,200		262,784	12,800	105,792
10/26	105,792	211,584		317,376		12,800
11/ 1		12,800		12,800	6,400	12,800
11/ 8		6,400		6,400		6,400
11/15	25,600	25,600		51,200	6,400	
11/22	3,200	3,200		6,400		
11/30						
12/ 6					3,200	6,400
12/14						6,400
12/20						6,400
12/27						

1913	Rotifer egg, winter	Rotifer egg, unidentified	Rotifer unidentified	Total Bdelloida	Anureaopsis fissa	Anureaopsis sp
1/ 5				2,000		
1/12				4,400		
1/19			800	54,096		
1/25			6,000	34,848		
2/ 2			6,400	113,792		
2/ 8		1,600	19,200	76,800		
2/15			3,200	16,000		
2/23	3,200		12,800	92,144		
3/ 1			1,600	33,600		
3/ 8			52,896	132,240		

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Rotifer egg, winter	Rotifer egg, unidentified	Rotifer unidentified	Total Bdelloida	Anureaopsis fissa	Anureaopsis sp
3/15			9,600	88,944		
3/23		16,000		188,336		
3/29			3,200	25,600		
4/ 5			6,400	16,000		
4/13			3,200	3,200		
4/19		1,600	6,400	6,400		
4/26		1,600				
5/ 3						
5/10	1,600		22,400	22,400		
5/17				6,400		
5/24	12,800			6,400		3,200
5/31			12,800	12,800		
6/ 7			12,800	12,800		
6/16						
6/21			3,200	3,200		
6/28				3,200		
7/ 5			3,200	3,200		6,400
7/12			1,600	4,800		6,400
7/19					38,400	
7/26				6,400		
8/ 2	105,792		158,688	174,688	6,400	
8/ 9					105,792	
8/15	3,200		32,000	64,000	12,800	
8/23			12,800	19,200	105,792	
8/31	105,792		211,584	224,384	105,792	
9/ 6					12,800	
9/13			25,600	25,600		
9/20			211,584	224,384	25,600	
9/27			105 792	105,792		
10/ 4			105,792	156,992	12,800	
10/11	25,600		38,400	64,000		
10/18	38,400		211,584	330,176		
10/26				12,800		
11/ 1	6,400			19,200	6,400	
11/ 8	52,896		12,800	19,200		
11/15			6,400	12,800		
11/22	1,600				3,200	
11/30						
12/ 6	3,200			9,600		
12/14	3,200			6,400		
12/20	1,600			6,400	1,600	
12/27			3,200	3,200		

1913	Asplanchna brightwellii	Asplanchnopus sp	Brachionus angularis	Brachionus angularis caudatus	Brachionus budapestenensis	Brachionus calyciflorus
1/ 5						800
1/12				400		1,200
1/19				400		1,200
1/25						4,000
2/ 2		1,600				1,600
2/ 8						44,800
2/15						132,240
2/23						41,600
3/ 1						6,400
3/ 8						3,200
3/15						19,200
3/23			6,400		79,344	16,000
3/29			9,600			16,000
4/ 5	6,400					
4/13						

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Asplanchna brightwellii	Asplanchnopus sp	Brachionus angularis	Brachionus angularis caudatus	Brachionus budapestenensis	Brachionus calyciflorus
4/19			6,400			1,600
4/26						6,400
5/ 3			3,200			
5/10						6,400
5/17						
5/24			3,200			
5/31						
6/ 7						
6/16				6,400		
6/21			6,400	22,400		
6/28	6,400		3,200	35,200		
7/ 5			3,200	105,792	3,200	
7/12	3,200	3 200		714,096	1,600	
7/19				83,200	19,200	6,400
7/26						
8/ 2				211,584	105,792	
8/ 9				105,792	19,200	19,200
8/15				1,005,024	12,800	19,200
8/23			19,200	12,800	105,792	
8/31			38,400	317,376		25,600
9/ 6				25,600		
9/13				38,400		12,800
9/20			12,800	317,376		12,800
9/27				51,200	12,800	25,600
10/ 4				38,400	12,800	38,400
10/11				211,584	12,800	12,800
10/18				64,000		25,600
10/26						25,600
11/ 1			6,400	25,600		6,400
11/ 8			52,896			
11/15					6,400	
11/22			3,200			
11/30			3,200		1,600	
12/ 6						
12/14						1,600
12/20						
12/27						

1913	Brachionus capsuliflorus	Brachionus egg attached female	Brachionus egg, attached male	Brachionus egg free female	Brachionus patulus	Brachionus plicatilis
1/ 5				800		
1/12				4,000		400
1/19				400		
1/25		400		800		800
2/ 2				1,600		1,600
2/ 8		19,200		3,200		3 200
2/15			105,792	79,344		
2/23		41,600	6,400	6,400		
3/ 1				3,200		3,200
3/ 8				6,400		3,200
3/15		16,000		52,896		3,200
3/23	3,200	12,800		52,896		6,400
3/29		6,400		3,200		3,200
4/ 5	3,200			3,200		
4/13		52,896				3,200
4/19						
4/26		3,200		3 200		3,200
5/ 3						
5/10						
5/17						

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Brachionus capsuliflorus	Brachionus egg, attached female	Brachionus egg, attached male	Brachionus egg, free female	Brachionus patulus	Brachionus plicatilis
5/24						
5/31						
6/ 7						
6/16		6,400	32,000			
6/21		3,200				
6/28		35,200		6,400		
7/ 5		1,600		79,344		
7/12				52,896	19,200	
7/19		19,200		105,792	25,600	
7/26		6,400			25,600	
8/ 2	12,800	3,200			25,600	
8/ 9	211,584			6,400		
8/15	25,600	3,200		6,400		
8/23		6,400		6,400	6,400	
8/31	25,600	64,000				
9/ 6	317,376	12,800			105,792	
9/13	38,400	12,800			12,800	
9/20	12,800	38,400		25,600		
9/27	64,000	51,200		12,800	25,600	
10/ 4	12,800	89,600		64,000		
10/11	12,800	12,800				
10/18		317,376		38,400		
10/26				25,600		
11/ 1	6,400	12,800		52,896		19,200
11/ 8						
11/15				6,400		
11/22						
11/30		3,200		52,896		
12/ 6				1,600	3,200	
12/14				1,600		
12/20						
12/27	3,200			1,600		

1913	Brachionus urceus	Diurella egg, free	Epiphanes clavulata	Epiphanes egg, attached female	Filinia egg, attached female	Filinia egg free
1/ 5						
1/12	1,200					
1/19	400					
1/25						
2/ 2	3,200					
2/ 8	3,200					
2/15	6,400					9,600
2/23					3,200	19,200
3/ 1					9,600	22,400
3/ 8					3,200	105,792
3/15						238,032
3/23					3,200	
3/29						
4/ 5						
4/13	1,600					
4/19	3,200					
4/26	3,200					1,600
5/ 3						
5/10						
5/17						3,200
5/24	6,400					
5/31						
6/ 7	38,400					
6/16	32,000	6,400				
6/21	9,600					1,600

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Brachionus urceus	Diurella egg, free	Epiphanes clavulata	Epiphanes egg, attached female	Filinia egg, attached female	Filinia egg, free
6/28	25,600	79,344			9,600	1,600
7/ 5		158,688				1,600
7/12	3,200	1,031,472				238,032
7/19	38,400	476,064				
7/26	12,800	317,376				3,200
8/ 2	105,792	423,168				528,960
8/ 9	51,200	158,688				3,200
8/15	6,400	528,960	12,800	6,400		158,688
8/23		1,110,816	64,000	12,800		158,688
8/31	38,400	317,376	76,800			528,960
9/ 6			12,800	12,800		
9/13	12,800	952,128	64,000	25,600		105,792
9/20	12,800		38,400			105,792
9/27		528,960	38,400			211,584
10/ 4		846,336	12,800			105,792
10/11		528,960				105,792
10/18	12,800	105,792	12,800			
10/26	12,800	25,600				
11/ 1						
11/ 8						
11/15						
11/22						
11/30						
12/ 6						
12/14	3,200					1,600
12/20						
12/27						

1913	Filinia longiseta	Keratella cochlearis	Keratella egg, attached	Keratella egg, free	Keratella quadrata	Lecane luna
1/ 5		400		1,200	1,200	
1/12		1,200	800	2,400	1,200	
1/19	400		1,200	19,836	1,600	
1/25		1,200		33,060	1,200	
2/ 2		3,200	1,600	17,600	20,800	
2/ 8		6,400	16,000	132,240	22,400	
2/15		12,800	6,400	132,240	6,400	3,200
2/23	79,344	99,200	25,600	6,400	6,400	
3/ 1	57,600	32,000	12,800			
3/ 8	290,928	238,032	158,688		19,200	
3/15	44,800	211,584	52,896		9,600	
3/23	38,400	555,408	211,584	1,600	79,344	
3/29	28,800	264,480	79,344	132,240	158,688	
4/ 5	3,200	264,480	1,600	79,344	19,200	
4/13	3,200	105,792	1,600	79,344	28,800	
4/19		793,440	1,600	185,136	105,792	
4/26		132,240	1,600	3,200	41,600	
5/ 3	1,600	6,400		1,600	79,344	
5/10	6,400			3,200	44,800	
5/17		38,400		105,792	3,200	
5/24				3,200	12,800	
5/31	12,800	12,800		105,792	38,400	
6/ 7		38,400		105,792		12,800
6/16		32,000	6,400	3,200	158,688	
6/21	6,400	211,584	9,600	158,688	9,600	
6/28	57,600	238,032	79,344	1,600		
7/ 5	3,200	555,408		185,136	12,800	6,400
7/12	9,600	1,798,464		423,168	3,200	
7/19		634,752		211,584	57,600	
7/26		25,600	6,400		12,800	

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Filinia longiseta	Keratella cochlearis	Keratella egg, attached	Keratella egg, free	Keratella quadrata	Lecane luna
8/ 2	....	158,688	....	3,200	12,800	....
8/ 9	....	....	....	....	12,800	....
8/15	....	....	....	....	38,400	....
8/23	....	....	....	....	12,800	....
8/31	....	....	....	....	64,000	....
9/ 6	....	211,584	12,800	....	25,000	....
9/13	....	38,400	....	....	....	....
9/20	....	25,600	....	....	....	....
9/27	....	....	....	....	12,800	12,800
10/ 4	....	....	105,792	....	211,584	....
10/11	....	12,800	25,600	....	128,000	....
10/18	....	1,269,504	105,792	....	528,960	....
10/26	105,792	2,115,840	317,376	211,584	25,600	....
11/ 1	....	2,486,112	793,440	211,584	51,200	....
11/ 8	....	846,336	528,960	317,376	52,896	....
11/15	....	476,064	12,800	6,400	....	....
11/22	....	449,616	185,136	52,896	6,400	....
11/30	....	211,584	52,896	1,600	52,896	....
12/ 6	....	12,800	6,400	3,200	3,200	....
12/14	3,200	3,200	6,400	1,600	25,600	....
12/20	....	6,400	6,400	52,896	3,200	....
12/27	....	....	3,200	....	6,400	....

1913	Notholca striata	Polyarthra trigla	Polyarthra trigla egg, attached female	Polyarthra trigla egg, attached male	Synchaeta sp.	Trichocerca capucina
1/ 5	....	800	....	....	....	....
1/12	....	2,400	....	....	400	....
1/19	400	1,200	....	....	400	....
1/25	1,200	2,000	....	....	....	....
2/ 2	1,600	12,800	....	....	3,200	3,200
2/ 8	....	57,600	....	....	....	....
2/15	3,200	19,200	....	....	....	....
2/23	3,200	6,400	....	....	9,600	....
3/ 1	....	12,800	3,200	....	3,200	....
3/ 8	....	105,792	....	....	3,200	....
3/15	3,200	3,200	....	....	3,200	....
3/23	3,200	12,800	....	....	19,200	....
3/29	....	16,000	....	....	16,000	....
4/ 5	16,000	6,400	....	....	....	....
4/13	....	6,400	3,200	....	....	....
4/19	....	....	....	....	9,600	....
4/26	....	79,344	....	....	9,600	....
5/ 3	1,600	6,400	....	....	....	....
5/10	....	86,400	....	....	....	....
5/17	....	....	....	....	....	....
5/24	....	158,688	....	....	....	....
5/31	....	12,800	....	....	....	....
6/ 7	12,800	....	....	....	....	....
6/16	....	....	....	....	....	....
6/21	....	25,600	....	....	....	....
6/28	....	105,792	....	....	32,000	3,200
7/ 5	....	3,200	....	....	16,000	3,200
7/12	6,400	79,344	....	....	132,240	....
7/19	....	19,200	....	....	25,600	....
7/26	....	32,000	....	....	6,400	....
8/ 2	....	....	....	....	....	....
8/ 9	....	6,400	....	....	6,400	....
8/15	6,400	3,200	....	....	6,400	....
8/23	....	105,792	....	....	6,400	....
8/31	....	12.800	....	....	12,800	....

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Notholca striata	Polyarthra trigla	Polyarthra trigla egg, attached female	Polyarthra trigla egg, attached male	Synchaeta sp	Trichocerca capucina
9/ 6		317,376				
9/13		51,200				
9/20	12,800	38,400				12,800
9/27		12,800	12,800		12,800	
10/ 4		25,600				
10/11						12,800
10/18	12,800	76,800		211,584	115,200	211,584
10/26		25,600			320,000	
11/ 1					264,480	
11/ 8					317,376	
11/15					51,200	
11/22	3,200	52,896			52,896	
11/30		25,600			22,400	
12/ 6		41,600			79,344	
12/14		105,792	3,200		79,344	
12/20		52,896		1,600	105,792	
12/27		3,200			79,344	1,600

1913	Trichocerca iernis	Trichotria curta	Total Ploima	Total Rotifera	Bosmina longirostris	Bosmina sp
1/ 5			5,200	7,200		
1/12			15,600	20,000		
1/19			27,436	81,532		
1/25			45,060	80,308	800	
2/ 2			73,600	197,392		
2/ 8			308,240	385,040		
2/15			516,816	532,816		
2/23			380,144	472,288		
3/ 1			168,000	201,600		
3/ 8			937,632	1,070,528		
3/15			737,152	826,096		
3/23			1,022,432	1,210,768		
3/29			733,952	769,552		
4/ 5			403,024	419,024		6,400
4/13			286,032	287,232		3,200
4/19			1,106,768	1,113,168		
4/26			293,184	293,184		1,600
5/ 3			100,144	100,144	3,200	
5/10			147,200	169,600		
5/17			150,592	156,992		
5/24			200,888	206,688		
5/31			182,592	195,392		
6/ 7			208,192	220,992		
6/16			277,088	277,088		
6/21			464,672	467,872		
6/28			687,168	690,368		
7/ 5	12,800	3,200	1,002,480	1,005,024		
7/12	79,344		3,573,584	3,578,384	3,200	
7/19	12,800		1,297,728	1,297,728	6,400	
7/26	105,792		560,768	567,168		
8/ 2	38,400		1,213,216	1,387,904	6,400	
8/ 9	19,200	6,400	579,968	579,968		
8/15	44,800		1,378,112	1,690,400	38,400	
8/23	158,688		782,052	1,201,828		
8/31	105,792		1,573,312	1,810,496	12,800	
9/ 6			1,067,328	1,067,328		
9/13	76,800		1,441,920	1,518,720	76,800	
9/20	211,584		903,552	1,179.136	51,200	
9/27	128,000		685,184	842,176	25,600	
10/ 4	64,000		794,368	1,220,160	12,800	

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Trichocerca iernis	Trichotria curta	Total Ploima	Total Rotifera	Bosmina longirostris	Bosmina sp
10/11	64,000		637,376	893,376		
10/18			2,830,016	3,422,976		
10/26			3,185,792	3,515,968		
11/ 1			3,949,312	3,981,312	6,400	
11/ 8			2,168,736	2,194,336		
11/15			565,664	629,664	6,400	
11/22			811,040	817,440		
11/30			427,872	427,872		
12/ 6			154,544	164,144	3,200	
12/14			239,536	245,936		
12/20			159,440	165,840		
12/27			98,544	101,744	6,400	

1913	Chydorus sp	Sida sp	Total Cladocera	Canthocamptus sp	Cyclops sp	Nauplius sp
1/ 5						
1/12						400
1/19			400		400	800
1/25			1,200		800	2,800
2/ 2						9,600
2/ 8						3,200
2/15						
2/23						3,200
3/ 1						
3/ 8						
3/15						
3/23						
3/29						1,600
4/ 5			6,400			1,600
4/13			3,200			
4/19						
4/26			1,600	3,200		
5/ 3			3,200			3,200
5/10						
5/17						
5/24						12,800
5/31						25,600
6/ 7						
6/16						
6/21						3,200
6/28					3,200	
7/ 5						3,200
7/12			3,200		3,200	6,400
7/19			6,400		12,800	6,400
7/26						
8/ 2			6,400		19,200	6,400
8/ 9					6,400	6,400
8/15	6,400		44,800		6,400	6,400
8/23	12,800		12,800	6,400	6,400	6,400
8/31		25,600	38,400		12,800	12,800
9/ 6						211,584
9/13	12,800	12,800	102,400		25,600	105,792
9/20	12,800		51,200			105,792
9/27	25,600		51,200			
10/ 4			12,800			
10/11					12,800	25,600
10/18	12,800		12,800			38,400
10/26				12,800		
11/ 1			6,400			
11/ 8						
11/15			6,400			

TABLE 2.—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Continued*)

1913	Chydorus sp	Sida sp	Total Cladocera	Canthocamptus sp	Cyclops sp	Nauplius sp
11/22						
11/30					6,400	
12/ 6	3,200		6,400			
12/14						
12/20						
12/27			6,400			

1913	Total Copepoda	Total Entomostraca	Chironomus larva	Glochidia	Insect larva	Macrobiotus sp
1/ 5						
1/12	400	400				400
1/19	1,200	1,600				
1/25	3,600	5,200		400	400	2,400
2/ 2	9,600	9,600				
2/ 8	3,200	3,200				
2/15				3,200		
2/23	3,200	3,200				3,200
3/ 1				3,200		
3/ 8	3,200	3,200				3,200
3/15						3,200
3/23						
3/29	1,600	1,600				
4/ 5	4,800	11,200				6,400
4/13		3,200				3,200
4/19						3,200
4/26	3,200	4,800				3,200
5/ 3	3,200	6,400				6,400
5/10						
5/17						6,400
5/24	12,800	12,800			6,400	
5/31	25,600	25,600		12,800		
6/ 7						
6/16				12,800		
6/21	3,200	3,200		6,400		
6/28	3,200	3,200		6,400		
7/ 5	3,200	3,200		16,000		
7/12	9,600	12,800		28,800		
7/19	19,200	25,600		32,000		
7/26						
8/ 2	25,600	32,000		105,792		
8/ 9	12,800	12,800				
8/15	12,800	57,600				
8/23	19,200	32,000				
8/31	25,600	64 000				
9/ 6	211,584	211,584		105,792		
9/13	131,792	233,792				
9/20	118,592	169,792				
9/27		51,200				
10/ 4		12,800				
10/11	38,400	38,400				
10/18	38,400	51,200				
10/26	12,800	12,800	105,792			
11/ 1		6,400				
11/ 8						
11/15		6,400				
11/22	3,200	3,200				
11/30	6,400	6,400				
12/ 6		6,400				
12/14						
12/20	. .					
12/27	. .	6,400	3,200			3,200

TABLE 2—ORGANISMS PER CUBIC METER IN PLANKTON OF SAN JOAQUIN RIVER IN 1913—(*Concluded*)

1913	Nematoda sp	Oligochaete sp	Water mite	Total Miscellaneous	Total Organisms
1/ 5					5,821,536
1/12				400	2,299,404
1/19		400		400	13,356,680
1/25		1,200		4,400	3,751,684
2/ 2					13,983,312
2/ 8		3,200		3,200	16,816,012
2/15				3,200	8,672,576
2/23				3,200	10,530,652
3/ 1				3,200	14,529,728
3/ 8				3,200	13,204,020
3/15				3,200	12,502,272
3/23	3,200			3,200	12,027,616
3/29					18,115,104
4/ 5				6,400	6,880,048
4/13				3,200	10,023,664
4/19				3,200	16,330,872
4/26				3,200	12,421,328
5/ 3				6,400	8,507,964
5/10					10,896,192
5/17	6,400		12,800	25,600	17,784,480
5/24				12,800	13,031,040
5/31				12,800	25,877,192
6/ 7					26,220,984
6/16				12,800	18,035,072
6/21				6,400	21,395,760
6/28			3,200	9,600	32 071,398
7/ 5				16,000	16,780,444
7/12				28,800	34,980,772
7/19				32,000	61,889,064
7/26					61,589,888
8/ 2				105,792	117,439,648
8/ 9					103,235,586
8/15					105,448,076
8/23					217,550,950
8/31					201,760,892
9/ 6				105,792	229,022,312
9/13				12,800	151,795,800
9/20					141,406,360
9/27					93,592,016
10/ 4					96,256,744
10/11					150,741,918
10/18					88,902,832
10/26				105,792	63,576,626
11/ 1					34,666,400
11/ 8					17,158,816
11/15					13,933,184
11/22					14,814,640
11/30					23,213,808
12/ 6					17,005,776
12/14					9,575,208
12/20					7,518,192
12/27				6,400	6,370,776

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913

1913	Spirillum undula	Total Bacteriaceae	Anabaena sp	Aphanocapsa sp	Coelosphaerium kutzingianum	Gloeocapsa conglomerata
1/11						
1/19						
1/25						
2/ 2	1,600	1,600				
2/ 8						
2/15						
2/23						
3/ 1			1,600			
3/ 8						
3/15						
3/23			1,600			
3/29						
4/ 5						
4/13			3,200			
4/19						
4/26			3,200			
5/ 3			6,400			
5/10			3,200		3,200	
5/17			16,000			
5/24						
5/31			1,600			
6/ 7			3,200	105,792		
6/16			9,600	3,200		
6/21	1,600	1,600	28 800	79 344		
6/28			476,064	185,136		
7/ 5			3,200	52,896		
7/12	1,600	1,600	2,036,496	264,480		185,136
7/19			4,601,952	105,792		
7/26			4,125,888	264,480		105,792
8/ 2			793,440	423,168		6,400
8/ 9			2,697,696	1,163,712		158,688
8/16						
8/23	3,200	3,200	1,586 880	158,688	3,200	
8/31			1,481,088			105,792
9/ 6	105,792	105,792	2,539,008			
9/13			1 692,672	211,584		
9/20				528,960		
9/27			12,800	12,800		
10/ 4			12,800	12,800		
10/11				211,584		
10/18			12,800			
10/26				6,400		
11/ 1			52,896		105,792	
11/ 8						
11/15	1,600	1,600				
11/22						
11/30						
12/ 6						
12/14	1,600	1,600	132,240			
12/20						
12/27						

1913	Gloeocapsa sp	Gomphosphaera aponina	Inactis tinctoria Agardh	Merismopedium glaucum	Microcystis sp	Nostoc sp
1/11						
1/19						
1/25						
2/ 2						
2/ 8		3,200				
2/15		3,200				

Table 3.—Organisms per Cubic Meter in Plankton of Smith's Canal in 1913—*(Continued)*

1913	Gloeocapsa sp	Gomphosphaera aponina	Inactis tinctoria Agardh	Merismopedium glaucum	Microcystis sp	Nostoc sp
2/23		3,200				
3/ 1		1,600				
3/ 8		1,600				
3/15	1,600	3,200				
3/23	79,344					
3/29	52,896					
4/ 5						
4/13		1,600			1,600	
4/19						3,200
4/26	1,600	158,688				
5/ 3	52,896					
5/10	1,600					
5/17						
5/24	1,600					
5/31	1,600					
6/ 7	1,600	6,400				
6/16						16,000
6/21	1,600				3,200	6,400
6/28	1,600					304,384
7/ 5	1,600				158,688	2,062,944
7/12	290,928	52,896			264,480	581,856
7/19	211,584				211,584	1,110,816
7/26	846,336	3,200			370,272	687,648
8/ 2	476,064				211,584	1,216,608
8/ 9	1,269,504	105,792			211,584	1,322,400
8/15	317,376					
8/23	581,856		1,163,712		32,000	6,876,480
8/31	317,376		6,030,144		12,800	3,491,136
9/ 6	423,168		7,934,400	12,800	12,800	740,544
9/13	1,057,920	76,800	952,128		64,000	1,057,920
9/20	952,128	317,376	1,586,880		12,800	2,644,800
9/27	740,544		11,319,744		25,600	634,752
10/ 4	740,544		423,168		317,376	317,376
10/11	317,376		528,960		211,584	317,376
10/18			317,376		25,600	
10/26	6,400				6,400	6,400
11/ 1	52,896				6,400	12,800
11/ 8	158,688		52,896	52,896		12,800
11/15	105,792			132,240	52,896	
11/22	52,896			52,896	12,800	
11/30	52,896			105,792		
12/ 6	79,344					
12/14	1,600					
12/20	133,840					
12/27						

1913	Oscillatoria formosa	Oscillatoria sp	Oscillatoria tenuis	Phormidium spp	Stigonema sp	Total Schizophyceae
1/11	400					400
1/19				3,200		3,200
1/25			400	66,120		66,520
2/ 2				1,600		1,600
2/ 8			1,600	3,200		7,000
2/15			79,344	52,896		135,440
2/23				185,136		188,336
3/ 1				1,600		4,800
3/ 8						1,600
3/15			52,896	52,896		110,592
3/23				79,344		150,288
3/29	52,896			317,376		476,064

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—*(Continued)*

1913	Oscillatoria formosa	Oscillatoria sp	Oscillatoria tenuis	Phormidium spp	Stigonema sp	Total Schizophyceae
4/ 5	3,200		3,200	79,344		250,832
4/13			1,600	132,240		140,240
4/19			1,600	105,792		110,592
4/26						163,488
5/ 3			3,200	3,200		68,696
5/10				1,600		9,600
5/17				52,896	16,000	84 896
5/24						1,600
5/31						3,200
6/ 7	6,400					123,392
6/16	9,600	3,200		79,344		120,944
6/21	9 600			1,600	1,600	132,144
6/28				1,600	1,600	758,800
7/ 5			1,600		1,600	2,130,240
7/12	1,600	1,600	3,200		52,896	3,735,568
7/19	3 200	317,376				6,562,304
7/26		370,272			6,400	6,780,294
8/ 2		317,376				2,651,200
8/ 9	6,400	687,648			158.688	7,623,424
8/15						323,726
8/23		211,584	3,200	476,064		11,252,352
8/31		317,376		1,798,464		13,554,174
9/ 6						11.662,720
9/13		105,792				5,218 716
9/20				317,376	211,584	6,571,904
9/27		105,792		528,960		13,380,992
10/ 4						1,824,064
10/11						1,599,680
10/18						355,776
10/26						25,600
11/ 1						230 784
11/ 8	6.400					283,680
11/15	3,200	1,600				295,728
11/22			3,200	52,896		174.688
11/30						158,688
12/ 6		52,896				132,240
12/14		1 600				135,440
12/20	9,600					9,600
12/27		52,896				52,896

1913	Actinastrum hantzschii	Actinastrum hantzschii (large)	Coelastrum microporum	Crucigenia lauterbornii	Pediastrum boryanum	Pediastrum duplex
1/11					400	400
1/19					6,400	
1/25					6,400	7,200
2/ 2					19,200	79,344
2/ 8					32 000	9,600
2/15					51,200	79,344
2/23	3,200				38,400	132,240
3/ 1	1,600				105,792	9,600
3/ 8	1,600				158,688	6,400
3/15	105,792				79,344	79,344
3/23	9,600				158 688	132,240
3/29	158,688				132,240	132,240
4/ 5	3,200				158,688	158,688
4/13	52,896				12,800	105,792
4/19	1,600				105,792	22,400
4/26	105,792	26.448			79,344	105,792
5/ 3		9,600			132,240	79,344
5/10	6,400				22,400	12,800

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Actinastrum hantzschii	Actinastrum hantzschii (large)	Coelastrum microporum	Crucigenia lauterbornii	Pediastrum boryanum	Pediastrum duplex
5/17					9,600	12,800
5/24	1,600				9,600	1,600
5/31					52,896	6,400
6/ 7					19,200	25,600
6/16	6,400	1,600				105,792
6/21	158,688	3,200			9,600	22,400
6/28	185,136	1,600			79,344	211,584
7/ 5	9,600	79,344				396,720
7/12	52,896	79,344			158,688	925,680
7/19		528,960			19,200	1,851,360
7/26	19,200	423,168	3,200		211,584	1,481,088
8/ 2	6,400	264,480				1,692,672
8/ 9		317,376			19,200	1,375,296
8/15					158,688	581,856
8/23	105,792	793,440	158,688		105,792	2,221,632
8/31		3,067,968	423,168		105,792	1,163,712
9/ 6	634,752	211,584	528,960	528,960	211,584	2,433,216
9/13		211,584	1,057,920			3,596,928
9/20	105,792	211,584	528,960		105,792	4,241,680
9/27		952,128	211,584	12,800	211,584	2,962,176
10/ 4	423,168	1,481,088	105,792	105,792	51,200	4,559,056
10/11		1,481,088	25,600		211,584	4,770,640
10/18		317,376		105,792	317,376	2,539,008
10/26	6,400	264,480			19,200	1,639,776
11/ 1		105,792	6,400		211,584	1,533,984
11/ 8	6,400	52,896	52,896		6,400	634,752
11/15	1,600				52,896	132,240
11/22	3,200	79,344			9,600	185,136
11/30	3,200	6,400	1,600		6,400	105,792
12/ 6		3,200			3,200	52,896
12/14						52,896
12/20						9,600
12/27					3,200	52,896

1913	Pediastrum simplex	Raphidium polymorphum	Richteriella botryoides	Scenedesmus obliquus	Scenedesmus quadricauda	Schroederia setigera
1/11					400	
1/19					3,200	
1/25					400	
2/ 2					1,600	
2/ 8	3,200				3,200	
2/15	1,600				105,792	
2/23					79,344	1,600
3/ 1	6,400				6,400	
3/ 8	3,200				132,240	
3/15	3,200		1,600	1,600	9,600	
3/23	52,896	1,600		1,600	132,240	
3/29	1,600	132,240			290,928	
4/ 5	1,600			3,200	105,792	
4/13		1,600			158,688	1,600
4/19		1,600		52,896	132,240	
4/26	52,896	1,600		1,600	105,792	
5/ 3		54,496		105,792	6,400	
5/10	1,600	79,344			3,200	
5/17		3,200		1,600		
5/24	3,200				3,200	
5/31				52,896	6,400	
6/ 7				3,200	132,240	
6/16					3,200	
6/21	3,200			3,200	9,600	

TABLE 3 —ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Pediastrum simplex	Raphidium polymorphum	Richteriella botryoides	Scenedesmus obliquus	Scenedesmus quadricauda	Schroederia setigera
6/28	1,600			3,200	264,480	
7/ 5		1,600		3,200	105,792	
7/12	52,896	1,600		3,200	290,928	
7/19	32,000	3,200			158,688	
7/26	6,400	3,200		105,792	317,376	3,200
8/ 2	105,792	3,200			476,064	
8/ 9	105,792	3,200		3,200	370,272	
8/15	105,792				899,232	
8/23	158,688	370,272	105,792	158,688	528,960	
8/31	105,792	317,376		12,800	846,336	
9/ 6	528,960		952,128	423,168	1,163,712	
9/13	12,800	211,584	25,600	211,584	528,960	
9/20	211,584		317,376	105,792	846,336	
9/27	25,600	224,384		423,168	1,269,504	
10/ 4	12,800	211,584		105,792	2,115,840	
10/11	211,584	105,792		423,168	1,692,672	211,584
10/18				211,584	846,336	52,896
10/26	12,800	52,896		317,376	1,110,816	
11/ 1	6,400	52,896		211,584	1,216,608	
11/ 8		211,584		158,688	846,336	
11/15		132,240		105,792	687,648	
11/22	3,200	1,600		3,200	290,928	1,600
11/30	1,600	79,344		1,600	158,688	
12/ 6		1,600			6,400	
12/14				3,200	3,200	
12/20				1,600	1,600	
12/27	1,600	132,240			52,896	

1913	Total Chlorophyceae	Asterionella gracillima	Asterionella gracillima (large)	Amphiprora alata	Amphora coffaeformis	Bacillaria paradoxa
1/11	1,200	773,604				2,000
1/19	9,600	6,083,040	1,600			4,800
1/25	14,000	3,153,924				
2/ 2	100,144	5,183,808	1,600			4,800
2/ 8	48,000	9,997,344				
2/15	237,936	2,062,944		1,600		6,400
2/23	257,984	2,644,800				
3/ 1	129,792	1,666,224				3,200
3/ 8	302,128	1,481,088		132,240		3,200
3/15	280,480	1 295,952	26,448			25,600
3/23	388,864	1,137,264	79,344	3,200		6,400
3/29	795,040	3,702,720	158,688	1,600		132,240
4/ 5	431,168	211,584		238 032		158,688
4/13	174,688	793,440	132,240	1,600		105,792
4/19	316,528	343,824	52,896	52,896		132,240
4/26	479,264	581,856	105,792			185,136
5/ 3	389,472	28,800				41,600
5/10	125,744	3,623,376				9,600
5/17	27,200	608,304	502 512	3,200		12,800
5/24	19,200	185,136				3,200
5/31	118,592	105,792				
6/ 7	180,240	819,888	1,031,472			16,000
6/16	116,992	2,353,872	2,803,488			12 800
6/21	211,584	3,067,968	3,120,864			6,400
6/28	746,944	899,232	502,512	1,600		38,400
7/ 5	597,856	238,032		1,600		12 800
7/12	1,644,576		1,600	105,792		1,428,192
7/19	2,593,408					1,904,256
7/26	2,577,408					5,183,808
8/ 2	2,548,508					4,760,640

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Total Chlorophyceae	Asterionella gracillima	Asterionella gracillima (large)	Amphiprora alata	Amphora coffaeformis	Bacillaria paradoxa
8/ 9	2,194,336				12,800	14,493,504
8/15	2,168 736			211,584		3,200
8/23	4,562,256	3,200				2,062,944
8/31	6,042,944					1,057,920
9/ 6	7,606,924					423,168
9/13	6,068,548			105,792		1 798,464
9/20	6,674,876					6,241,728
9/27	6,292,928					2,221,632
10/ 4	9,222,112					2,327,424
10/11	9,133,712			105,792		740,544
10/18	4,337,472			105,792		423,168
10/26	3,466,640	52,896				211,584
11/ 1	3,355,248		6,400			105,792
11/ 8	1,811,264	6,400	52,896			102,400
11/15	1,112,416	22,400	158,688			28,800
11/22	579,408	79 344	185,136			370,272
11/30	364,624	1,600	1,600			290,928
12/ 6	67,296	5,316,048		1,600		1,613,328
12/14	59,296	1,877,808	634,752		1,600	740,544
12/20	12,800	238,032				502,512
12/27	242,832	158,688				264,480

1913	Cocconeis pediculus	Cocconeis sp	Cyclotella spp	Cymatopleura solea	Cymbella affinis	Cymbella cymbiformis
1/11			146,264			
1/19			1,560,432			
1/25			958,740			1,600
2/ 2			1,137,264	1,600		
2/ 8			1,481,088			
2/15			1,798,464			22,400
2/23			6,506,208			
3/ 1	1,600	1,600	16,794,480	6,400	12,800	52,896
3/ 8			6,109,488	6,400		
3/15			4,839,984	3,200		6,400
3/23			3,491,136	3,200		
3/29	1,600		4,496,160	9,600	52,896	9,600
4/ 5			1,322,400	3,200	1,600	6,400
4/13		52,896	1,745,568	12,800	3,200	
4/19			3,358,896	6,400		3,200
4/26			2,062,944		105,792	
5/ 3			3,782,064		1,600	
5/10	1,600		1,533,984		52,896	
5/17			2,248,080	3,200	1,600	3,200
5/24			899,232		3,200	3,200
5/31			581,856			
6/ 7			819,888		3,200	
6/16			1,295,952	3,200	3,200	
6/21			1,560,432		1,600	3,200
6/28			3,649,824	3,200	1,600	
7/ 5			3,226,656		1,600	
7/12			5,316,048		3,200	
7/19			7,405,440			
7/26			8,410,464	19,200		6,400
8/ 2			10,367,616			
8/ 9			6,823,584	3,200		6,400
8/15			7,669,920	6,400		
8/23	3,200		13,594,272	25,600		
8/31			14,281,920			12,800
9/ 6			12,906,624	25,600		25,600

Table 3 —Organisms Per Cubic Meter in Plankton of Smith's Canal in 1913—(*Continued*)

1913	Cocconeis pediculus	Cocconeis sp	Cyclotella spp	Cymatopleura solea	Cymbella affinis	Cymbella cymbiformis
9/13			9,521,292	12,800		
9/20			15,128,256			12,800
9/27			17,773,056			
10/ 4			22,765,328			
10/11			22,342,160		105,792	
10/18	105,792		24,667,584			
10/26			39,407,520	6,400	52,896	
11/ 1			13,488,480	6,400		6,400
11/ 8			6,559,104		6,400	12,800
11/15			2,697,696			3,200
11/22	1,600		2,540,608		1,600	12,800
11/30			2,196,784		1,600	3,200
12/ 6			2,327,424	6,400	52,896	
12/14			1,297,552	6,400		
12/20			1,533,984	12,800		6,400
12/27			1,719,120		52,896	

1913	Cymbella pusilla	Cymbella prostrata	Cymbella sp	Cymbella tumida	Diatom unidentified	Epithemia ocellata
1/11			800			
1/19						
1/25						
2/ 2			1,600		3,200	
2/ 8						
2/15	1,600				79,344	
2/23	1,600		1,600			
3/ 1			3,200		3,200	3,200
3/ 8				3,200	52,896	3,200
3/15	1,600			6,400		
3/23						
3/29					52,896	
4/ 5				3,200	1,600	
4/13					1,600	3,200
4/19						
4/26				1,600		52,896
5/ 3				3,200	79,344	
5/10			1,600	9,600		
5/17				3,200		
5/24						
5/31						
6/ 7				3,200		3,200
6/16		3,200				6,400
6/21		3,200		6,400		9,600
6/28				1,600		3,200
7/ 5				1,600		
7/12				52,896		3,200
7/19				6,400		
7/26				12,800		12,800
8/ 2						
8/ 9				6,400		
8/15				6,400		
8/23						12,800
8/31				12,800		
9/ 6				12,800		12,800
9/13						
9/20						
9/27						
10/ 4						12,800
10/11						

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Cymbella pusilla	Cymbella prostrata	Cymbella sp	Cymbella tumida	Diatom unidentified	Epithemia ocellata
10/18				12,800		
10/26						
11/ 1						6,400
11/ 8				6,400		
11/15						
11/22				1,600		6,400
11/30						1,600
12/ 6				6,400		9,600
12/14						
12/20						6,400
12/27						6,400

1913	Eunotia flexuosa	Eunotia sp	Fragilaria capucina	Fragilaria crotonensis	Fragilaria sp	Gomphonema constrictum
1/11			1,200		400	
1/19			9,600			
1/25			19,836			
2/ 2			9,600			
2/ 8			6,400			
2/15			52,896			
2/23			16,000	3,200		
3/ 1			9,600			
3/ 8			79,344		3,200	
3/15			79,344			
3/23			22,400			
3/29			185,136			
4/ 5			79,344			
4/13			79,344			
4/19			6,400			
4/26			158,688			3,200
5/ 3			9,600			
5/10			12,800			
5/17			12,800			
5/24			19,200			1,600
5/31			1,600			
6/ 7			3,200		1,600	1,600
6/16			28,800			1,600
6/21			105,792			1,600
6/28			3,200			
7/ 5			9,600			
7/12			3,200		1,600	
7/19			6,400			
7/26			6,400			
8/ 2						
8/ 9			6,400			3,200
8/15					6,400	
8/23						
8/31						
9/ 6				105,792		
9/13			12,800	105,792		
9/20				105,792		
9/27			105,792			
10/ 4		105,792	12,800			
10/11				12,800		
10/18						
10/26			52,896	6,400		
11/ 1		52,896	52,896	52,896		
11/ 8				6,400		
11/15		1,600	9,600			

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Eunotia flexuosa	Eunotia sp	Fragillaria capucina	Fragillaria crotonensis	Fragillaria sp	Gomphonema constrictum
11/22			6,400	3,200		
11/30						1,600
12/ 6			3,200		1,600	
12/14	1,600					
12/20	6,400					
12/27		1,600	3,200			

1913	Gomphonema olivaceum	Gomphonema sp	Gomphonema subclavatum	Gyrosigma acuminatum	Gyrosigma kutzingii	Gyrosigma scalproides
1/11					400	
1/19					3,200	
1/25					800	
2/ 2					6,400	
2/ 8					6,400	
2/15					105,792	
2/23				3,200	3,200	
3/ 1				52,896	105,792	
3/ 8						
3/15					3,200	1,600
3/23					3,200	132,240
3/29				1,600	132,240	1,600
4/ 5		1,600			79,344	
4/13					9,600	
4/19					79,344	1,600
4/26					6,400	
5/ 3					3,200	
5/10					3,200	
5/17		1,600			1,600	1,600
5/24					12,800	3,200
5/31						
6/ 7	1,600				12,800	52,896
6/16					12,800	
6/21					9,600	1,600
6/28					12,800	1,600
7/ 5				1,600	3,200	
7/12					105,792	
7/19					32,000	
7/26					476,064	6,400
8/ 2					158,688	317,376
8/ 9					211,584	1,481,088
8/15				211,584	105,792	1,005,024
8/23	3,200			105,792	370,272	2,697,696
8/31				211,584	317,376	1,586,880
9/ 6				105,792	423,168	740,544
9/13					211,584	317,376
9/20				317,376	105,792	317,376
9/27					12,800	211,584
10/ 4			12,800		105,792	317,376
10/11			105,792		38,400	211,584
10/18			105,792			105,792
10/26				105,792	12,800	423,168
11/ 1						6,400
11/ 8					105,792	158,688
11/15					6,400	79,344
11/22					52,896	132,240
11/30				9,600	6,400	3,200
12/ 6					52,896	52,896
12/14					52,896	
12/20				3,200	6,400	52,896
12/27					3,200	105,792

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Melosira granulata	Melosira granulata *A* (small)	Melosira varians	Navicula affinis	Navicula alpestris	Navicula bacillum
1/11			4,800			
1/19	1,600		211,584	1,600		
1/25	119,016		19,836			
2/ 2	449,616		9,600	1,600		
2/ 8	952,128		25,600			
2/15	899,232		264,480			
2/23	1,560,432		9,600			
3/ 1	687,648		264,480		1,600	
3/ 8	1,084,368		105,792			
3/15	4,152,336		185,136	6,400	105,792	
3/23	1,877,808	6,321,072	423,168	105,792	105,792	
3/29	2,353,872	9,045,216	396,720	1,600	132,240	185,136
4/ 5	872,784	132,240	105,792		1,600	
4/13	5,104,464	740,544	158,688	185,136	79,344	
4/19	5,765,664	634,752	9,600	1,600	79,344	
4/26	9,203,904	581,856	238,032	79,344	3,200	79,344
5/ 3	1,560,432	211,584	79,344			105,792
5/10	2,010,048	158,688	105,792			52,896
5/17	3,649,824	105,792	79,344		1,600	132,240
5/24	3,279,552		19,200		52,896	3,200
5/31	1,454,640	1,600	3,200			3,200
6/ 7	5,078,016		6,400		1,600	52,896
6/16	6,426,864		79,344		1,600	52,896
6/21	8,119,536		132,240			52,896
6/28	14,652,192		6,400		3,200	1,600
7/ 5	9,891,552		185,136			52,896
7/12	16,503,552		158,688		1,600	
7/19	13,647,168					105,792
7/26	24,437,952		12,800			3,200
8/ 2	34,170,816		6,400		3,200	105,792
8/ 9	64,321,536		158,688		3,200	211,584
8/15	86,643,648		211,584			3,200
8/23	84,845,184		105,792		105,792	
8/31	88,971,072					
9/ 6	193,810,944		25,600		211,584	105,792
9/13	75,439,744					211,584
9/20	127,912,576		317,376			105,792
9/27	72,265,984					211,584
10/ 4	53,214,576		105,792		105,792	
10/11	60,524,224		12,800		211,584	105,792
10/18	27,515,968		105,792			
10/26	22,057,632		6,400		105,792	
11/ 1	15,445,632		6,400			
11/ 8	6,612,000		19,200			105,792
11/15	2,697,696		3,200			1,600
11/22	2,115,840		52,896		52,896	
11/30	3,914,304		6,400		3,200	
12/ 6	2,327,424		79,344		52,896	1,600
12/14	1,507,536		52,896			79,344
12/20	661,200		25,600		1,600	
12/27	1,110,816		185,136			52,896

1913	Navicula didyma	Navicula dubia	Navicula gracilis	Navicula sp	Navicula viridis	Nitzschia acicularis
1/11						
1/19				52,896		80,944
1/25			800			59,508
2/ 2			158,688	1,600	4,800	185,136
2/ 8	3,200		158,688	1,600		158,688

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Navicula didyma	Navicula dubia	Navicula gracilis	Navicula sp	Navicula viridis	Nitzschia acicularis
2/15	3,200		264,480	79,344	12,800	132,240
2/23			6,400		3,200	79,344
3/ 1			290,928	105,792	1,600	158,688
3/ 8	1,600		185,136	82,544	3,200	79,344
3/15			290,928	3,200		105,792
3/23	3,200		290,928	1,600		211,584
3/29	1,600		476,064	1,600	1,600	343,824
4/ 5			581,856	4,800	6,400	238,032
4/13			185,136	6,400	3,200	264,480
4/19			238,032	1,600	3,200	264,480
4/26	1,600		608,304	3,200		476,064
5/ 3			105,792		1,600	52,896
5/10			132,240	3,200		105,792
5/17			158,688		3,200	211,584
5/24			211,584		3,200	185,136
5/31						132,240
6/ 7			317,376		3,200	211,584
6/16			370,272	3,200	3,200	846,336
6/21			79,344	6,400		661,200
6/28			185,136			1,005,024
7/ 5			1,600			819,888
7/12	52,896		634,752		3,200	608,304
7/19			105,792			793,440
7/26			1,798,464	3,200	12,800	687,648
8/ 2			740,544			793,440
8/ 9		6,400	2,062,944		12,800	634,752
8/15			49,722,240		6,400	158,688
8/23			3,385,344		6,400	423,168
8/31		105,792	2,644,800			3,067,968
9/ 6			1,904,256			3,385,344
9/13			423,168		12,800	1,269,504
9/20			2,327,424			528,960
9/27			1,375,296		12,800	1,481,088
10/ 4			952,128		25,600	528,960
10/11			1,163,712			211,584
10/18			740.544			211,584
10/26		52,896	317,376			105,792
11/ 1		105,792	52,896			158,688
11/ 8	52,896		158,688		6,400	317,376
11/15			52,896	3,200	6,400	502,512
11/22			185,136		9,600	211,584
11/30	3,200		158,688			290,928
12/ 6			370,272	6,400	52,896	502,512
12/14		1,600	158,688		3,200	132,240
12/20			185,136			79,344
12/27	3,200		317,376		3,200	132,240

1913	Nitzschia angularis	Nitzschia sigma	Nitzschia sigmoidea	Nitzschia vermicularis	Pinnularia acrosphaeria	Pleurostauron parvulum
1/11						39,672
1/19				1,600		317,376
1/25						72,732
2/ 2	9,600			3,200		264,480
2/ 8			1,600	52,896		211,584
2/15	6,400			105,792	9,600	158,688
2/23	3,200			9,600		211,584
3/ 1			9,600	3,200		740,544
3/ 8	3,200	1,600		1,600		290,928
3/15			79,344	6,400		476,064

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Nitzschia angularis	Nitzschia sigma	Nitzschia sigmoidea	Nitzschia vermicularis	Pinnularia acrosphaeria	Pleurostauron parvulum
3/23	3,200		3,200			370,272
3/29	3,200		52,896			423,168
4/ 5			52,896	3,200		343,824
4/13		12,800				581,856
4/19	6,400	3,200				211,584
4/26		3,200				132,240
5/ 3		3,200				211,584
5/10						211,584
5/17	3,200	3,200		3,200		
5/24		6,400		6,400		132,240
5/31						
6/ 7		3,200				1,600
6/16	12,800					158,688
6/21	1,600	1,600	6,400	3,200	1,600	52,896
6/28	3,200			1,600		
7/ 5				6,400		
7/12	9,600			79,344		52,896
7/19						158,688
7/26	25,600					158,688
8/ 2		6,400		3,200		3,200
8/ 9	6,400	264,480				158,688
8/15	105,792	105,792		105,792		105,792
8/23	6,400	211,584		158,688		158,688
8/31		317,376				
9/ 6		211,584		105,792		
9/13	12,800	211,584		105,792		
9/20		105,792				
9/27		211,584		211,584		105,792
10/ 4	12,800	105,792		38,400		105,792
10/11	12,800			12,800		
10/18		12,800		12,800		105,792
10/26	12,800				6,400	52,896
11/ 1		52,896		6,400		52,896
11/ 8	52,896	12,800				211,584
11/15		1,600				52,896
11/22	3,200	6,400		6,400		1,600
11/30	3,200					105,792
12/ 6	3,200	52,896				132,240
12/14		52,896				52,896
12/20		9,600				52,896
12/27		3,200		6,400		185,136

1913	Stauroneis phoenicenteron	Surirella sp	Synedra radians	Synedra ulna	Total Bacillariaceae	Closterium acerosum
1/11		400		26,448	995,988	
1/19		17,600		449,616	8,850,184	
1/25		5,600		469,452	4,882,644	3,200
2/ 2		65,600		343,824	7,847,616	3,200
2/ 8		19,200		238,032	13,286,048	1,600
2/15		114,544		343,824	6,526,064	3,200
2/23		94,496		396,720	11,554,384	
3/ 1		132,240		502,512	21,603,120	
3/ 8		48,000		290,928	10,066,896	6,400
3/15		158,688		793,440	12,653,248	3,200
3/23		132,240		238,032	15,174,656	
3/29		185,136		476,064	23,028,112	
4/ 5		132,240		370,272	5,009,024	3,200
4/13	3,200	185,136		528,960	10,329,424	
4/19		79,344		423,168	11,761,264	

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Stauroneis phoenicenteron	Surirella sp.	Synedra radians	Synedra ulna	Total Bacillariaceae	Closterium acerosum
4/26		54,400		185,136	14,915,728	6,400
5/ 3		35,200		6,400	6,323,232	
5/10		105,792		317,376	8,531,408	
5/17		158,688		185,136	8,256,480	
5/24		60,800		105,792	5,198,768	
5/31				1,600	2,285,728	
6/ 7	1,600	132,240		132,240	8,722,096	
6/16	3,200	79,344		238,032	14,880,432	
6/21		211,584		238,032	17,599,024	3,200
6/28		105,792		1,190,160	22,537,552	
7/ 5		132,240		343,824	15,092,112	
7/12		449,616		343,824	26,131,376	6,400
7/19		211,584	105,792	158,688	24,800,128	
7/26		1,428,192	793,440	267,680	43,673,600	12,800
8/ 2		687,648	264,480	211,584	53,816,832	6,400
8/ 9		4,125,888	158,688		95,438,688	37,400
8/15	3,200	1,586,880	476,064	370,272	149,512,496	
8/23		2,274,528	1,057,920	158,688	113,258,240	12,800
8/31		1,163,712	528,960	4,125,888	118,406,848	38,400
9/ 6		634,752	423,168	3,808,512	220,996,096	76,800
9/13		211,584	423,168	5,924,364	96,437,784	12,800
9/20		634,752	317,376	2,856,384	157,322,752	25,600
9/27		528,960	1,586,880	2,539,008	99,961,216	
10/ 4		423,168	1,269,504	1,904,256	84,452,672	
10/11		317,376	846,336	2,221,632	89,303,502	12,800
10/18		740,544	634,752	1,692,672	57,291,968	
10/26		634,752	158,688	476,064	64,325,240	12,800
11/ 1		476,064	158,688	370,272	30,671,584	6,400
11/ 8	52,896	528,960	264,480	528,960	15,042,976	
11/15		52,896	211,584	158,688	6,757,696	3,200
11/22		185,136	52,896	79,344	6,35 ,424	6,400
11/30		158,688	52,896	132,240	7,324,400	3,200
12/ 6	3,200	264,480		290,928	13,506,832	3,200
12/14		105,792		238,032	7,003,072	3,200
12/20		264,480	132,240	105,792	3,890,112	
12/27		79,344	1,600	185,136	4,581,056	

1913	Closterium acuminatum	Closterium rostratum	Cosmarium sp	Mougeotia sp.	Spirogyra protecta	Staurastrum *A*
1/11					1,200	
1/19				1,600	6,400	
1/25				400		
2/ 2					1,600	
2/ 8						
2/15						1,600
2/23				1,600		79,344
3/ 1						
3/ 8						185,136
3/15					3,200	6,400
3/23						
3/29						52,896
4/ 5			1,600	1,600	6,400	
4/13	1,600			1,600		
4/19						
4/26						1,600
5/ 3						
5/10					1,600	
5/17				3,200		
5/24						

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Closterium acuminatum	Closterium rostratum	Cosmarium sp	Mougeotia sp	Spirogyra protecta	Staurastrum *A*
5/31				1,600		
6/ 7				9,600		
6/16	6,400					
6/21			1,600			
6/28						52,896
7/ 5	3,200					105,792
7/12	6,400			238,032		132,240
7/19				211,584		12,800
7/26				423,168		105,792
8/ 2				264,480		105,792
8/ 9	6,400			1,322,400		317,376
8/15		3,200		3,200		3,200
8/23		105,792		3,967,200		105,792
8/31		12,800		4,866,432		
9/ 6				1,586,880		211 584
9/13		105,792		317,376		423,168
9/20				105,792		3,067,968
9/27						317,376
10/ 4				105,792		423,168
10/11						528,960
10/18						25,600
10/26				52,896		264,480
11/ 1						12,800
11/ 8						
11/15				211,584		
11/22				52,896		3,200
11/30				1,600		3,200
12/ 6		1,600			3,200	3,200
12/14					3,200	1,600
12/20						
12/27					6,400	

1913	Staurastrum sp	Total Conjugatae	Total Chlorophyll bearing	Total Algae	Ceratium hirundinella	Cercomonas crassicauda
1/11		1,200	999,988	998,788		
1/19		8,000	9,938,504	8,870,984		
1/25		3,600	6,508,748	4,966,764		
2/ 2		4,800	9,223,664	7,955,760		
2/ 8		1,600	17,480,488	13,342,648		
2/15		4,800	10,570,064	6,904,240		
2/23		84,144	17,567,024	12,084,848		
3/ 1			22,767,488	21,737,712		
3/ 8		191,536	11,030,128	10,562,160		
3/15		12,800	13,969,056	13,057,120		
3/23		100,000	17,638,720	15,813,808		
3/29		52,896	25,649,664	24,352,112		
4/ 5		12,800	5,868,912	5,703,824		
4/13		3,200	11,054,624	10,647,552		
4/19			12,431,216	12,188,384		
4/26		8,000	16,141,088	15,566,480		
5/ 3			7,444,200	6,781,400		
5/10		1,600	8,998,528	8,668,352		
5/17		3,200	8,540,968	8,371,776		
5/24		3,200	5,364,608	5,222,768		
5/31		1,600	2,574,208	2,409,120		
6/ 7		9,600	9,462,448	9,035,328		
6/16		9,600	15,295,408	15,127,968		3,200
6/21		4,800	18,320,928	17,949,056		3,200
6/28		52,896	24,406,320	24,096,192		3,200

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Staurastrum sp	Total Conjugatae	Total Chlorophyll bearing	Total Algae	Ceratium hirundinella	Cercomonas crassicauda
7/ 5		108,992	19,267,600	17,929,200		
7/12		383,072	33,831,696	31,896,192		
7/19	211,584	435,968	36,948,320	28,391,808	6,400	
7/26	105,792	652,952	58,738,174	53,684,254		
8/ 2	317,376	694,048	62,336,096	59,710,588		
8/ 9	105,792	1,789,368	111,133,112	107,045,816		
8/15		115,392	161,112,670	152,120,350		
8/23	317,376	4,508,960	138,246,256	133,585,008		
8/31		4,917,632	147,390,462	142,921,598		105,792
9/ 6	528,960	830,144	247,981,772	241,201,676		
9/13		859,136	114,001,764	108,584,184	12,800	
9/20		3,199,362	177,590,200	173,768,894		
9/27	105,792	423,168	125,264,912	120,058,304		105,792
10/ 4		488,960	101,844,780	95,987,808		
10/11		554,560	104,095,392	100,591,454		
10/18	211,594	237,184	65,078,784	62,222,400		
10/26		330,176	70,077,512	68,147,656	52,896	
11/ 1		19,200	38,316,112	34,276,816		
11/ 8			22,222,336	17,137,920		
11/15		214,784	11,703,204	8,382,224		
11/22		62,496	16,219,536	7,168,016		
11/30		14,000	11,808,016	7,861,712		
12/ 6		9,600	16,429,664	13,715,968		
12/14		11,200	10,081,776	7,210,608		
12/20			6,232,912	3,912,512		
12/27		6,400	7,511,136	4,883,184		

1913	Chlamydomonas sp	Chromulina sp	Cryptomonas sp	Dinobryon sertularia	Eudorina elegans	Euglena viridis
1/11					1,200	
1/19		1,005,024			8,000	
1/25		1,500,924			3,200	
2/ 2		952,128			105,792	52,896
2/ 8	52,896	3,782,064			16,000	
2/15		3,253,104			9,600	3,200
2/23		5,527,632		3,200	32,000	6,400
3/ 1		846,336			44,800	
3/ 8		105,792			35,200	
3/15		396,720		1,600	60,800	
3/23		1,322,400			211,584	
3/29		634,752		1,600	264,480	
4/ 5		79,344			3,200	
4/13		158,688		1,600	32,000	3,200
4/19		185,136			3,200	
4/26		238,032			12,800	1,600
5/ 3		290,928		52,896		
5/10		105,792		105,792	6,400	1,600
5/17		105,792			49,000	
5/24	1,600	1,600		52,896		3,200
5/31				52,896	3,200	
6/ 7		52,896		105,792	28,800	
6/16		79,344		16,000	22,400	3,200
6/21		105,792			79,344	
6/28		1,600		1,600	16,000	
7/ 5		793,440		1,600	6,400	52,896
7/12		1,401,744			185,136	79,344
7/19		2,486,112			51,200	3,200
7/26		3,702,720			105,792	158,688

Table 3.—Organisms Per Cubic Meter in Plankton of Smith's Canal in 1913—(*Continued*)

1913	Chlamydomonas sp	Chromulina sp	Cryptomonas sp	Dinobryon sertularia	Eudorina elegans	Euglena viridis
8/ 2		2,380,320			32,000	
8/ 9		1,957,152			1,163,712	3,200
8/15		8,569,152				
8/23		4,231,680			6,400	3,200
8/31		3,279,552				105,792
9/ 6		5,183,808	105,792			105,792
9/13		5,078,016			25,600	105,792
9/20		2,750,592			317,376	
9/27		4,453,264			105,792	
10/ 4		5,501,196			25,600	
10/11		2,644,800			105,792	
10/18		2,856,384				
10/26		1,639,776			6,400	
11/ 1		3,438,240			211,584	
11/ 8		4,601,952		52,896	105,792	
11/15		3,094,416			3,200	
11/22		8,727,840	1,600	3,200	22,400	
11/30		3,623,376	52,896	52,896	9,600	
12/ 6		2,512,560		3,200	52,896	
12/14		2,962,176	1,600		52,896	
12/20		3,253,104			9,600	
12/27		2,486,112			6,400	

1913	Flagellate unidentified	Hemidinium nasutum	Mallomonas sp	Pandorina morum	Peridinium cinctum	Peridinium sp
1/11						
1/19				1,600		
1/25	1,600			2,400		
2/ 2	52,896					
2/ 8				22,400		
2/15				3,200		
2/23				25,600		6,400
3/ 1				6,400		
3/ 8				9,600		
3/15				132,240		
3/23				79,344		
3/29	79,344			105,792		
4/ 5	79,344			3,200		
4/13						
4/19						
4/26	1,600			3,200	52,896	
5/ 3	1,600			185,136		
5/10	1,600					
5/17	3,200		3,200	6,400		
5/24				3,200		
5/31				3,200		
6/ 7			1,600			52,896
6/16				3,200		
6/21						
6/28						
7/ 5				1,600	105,792	
7/12				3,200		1,600
7/19			6,400			
7/26				6,400	3,200	
8/ 2		158,688		3,200		
8/ 9		264,480				
8/15						
8/23						
8/31		105,792		105,792		

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Flagellate unidentified	Hemidinium nasutum	Mallomonas sp	Pandorina morum	Peridinium cinctum	Peridinium sp
9/ 6		528,960				
9/13					105,792	
9/20		105,792			211,584	
9/27		105,792				
10/ 4						
10/11		105,792			317,376	
10/18						
10/26						
11/ 1				6,400	158,688	
11/ 8				6,400		
11/15				1,600		
11/22				25,600		
11/30				19,200		
12/ 6				6,400		
12/14				3,200		
12/20				3,200		
12/27						

1913	Phacus pleuronectes	Platydorina caudata	Pleodorina californica	Pleodorina illinoisensis	Pteromonas sp	Syncrypta volvox
1/11						
1/19						
1/25						
2/ 2						
2/ 8						
2/15						52,896
2/23						
3/ 1						
3/ 8						
3/15						
3/23						
3/29						
4/ 5						
4/13						
4/19						
4/26						
5/ 3						
5/10						
5/17						
5/24						
5/31						
6/ 7						
6/16					52,896	
6/21						
6/28						
7/ 5			3,200		1,600	
7/12						
7/19						
7/26	3,200		6,400			
8/ 2		32,000	12,800			
8/ 9		64,000	105,792			
8/15						
8/23						
8/31		25,600				
9/ 6		12,800	51,200	25,600		12,800
9/13		76,800	12,800			
9/20		12,800	105,792			
9/27		12,800				
10/ 4		12,800				

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Phacus pleuronectes	Platydorina caudata	Pleodorina californica	Pleodorina illinoisensis	Pteromonas sp	Syncrypta volvox
10/11						
10/18						
10/26			12,800			
11/ 1		6,400		6,400		
11/ 8						
11/15			9,600	3,200		
11/22	52,896			6,400		
11/30	1,600					
12/ 6						
12/14						
12/20						
12/27						

1913	Synura uvella	Trachelomonas euchlora	Trachelomonas volgensis	Trachelomonas volvocina	Volvox globator	Total Mastigophora
1/11						1,200
1/19				52,896		1,067,520
1/25		400		33,060		1,541,984
2/ 2				105,792		1,269,504
2/ 8		52,896		211,584		4,137,840
2/15		52,896		290,928		3,665,824
2/23		1,600		79,344		5,682,176
3/ 1		52,896		79,344		1,029,776
3/ 8				317,376		467,968
3/15		105,792		211,584		911,936
3/23		132,240		79,344		1,824,912
3/29		105,792		105,792		1,297,552
4/ 5						165,088
4/13		158,688		52,896		407,072
4/19		52,896		1,600		242,832
4/26		132,240		132,240		574,608
5/ 3				132,240		662,800
5/10				105,792		330,176
5/17				1,600		169,192
5/24				79,344		141,840
5/31				105,792		165 088
6/ 7		132,240		52,896		427,120
6/16				1,600		167,440
6/21		52,896		79,344		373,472
6/28		132,240		158,688		310,128
7/ 5				370,272		1,338,400
7/12				264,480		1,937,104
7/19		3,200				2,556,512
7/26		370,272		581,856		5,053,920
8/ 2						2,625,408
8/ 9				528,960		4,087,296
8/15				423,168		8,992,320
8/23	105,792			317,376		4,664,448
8/31				740,544		4,468,864
9/ 6	105,792		105,792	634,752	12,800	6,885,888
9/13						5,417,600
9/20				317,376		3,821,306
9/27				423,168		5,206,608
10/ 4				317,376		5,856,972
10/11	12,800		105,792	211,584		3,503,936
10/18						2,856,384
10/26				211,584		1,929 856
11/ 1				211,584		4,039,296
11/ 8			105,792	211,584		5,084,416
11/15				211,584		3,322,600

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Synura uvella	Trachelomonas euchlora	Trachelomonas volgensis	Trachelomonas volvocina	Volvox globator	Total Mastigophora
11/22				211,584		9,051,520
11/30			1,600	185,136		3,946,304
12/ 6	1,600		1,600	132,240	3,200	2,713,696
12/14				52,896		2,872,768
12/20	1,600			52,896		2,320,400
12/27			3,200	132,240		2,627,952

1913	Amoeba proteus	Amoeba radiosa	Arcella vulgaris	Cyphoderia ampulla	Difflugia corona	Difflugia globulosa
1/11						
1/19			3,200			
1/25						
2/ 2						
2/ 8						
2/15				6,400		
2/23						
3/ 1						
3/ 8						1,600
3/15				3,200		3,200
3/23						
3/29						
4/ 5			3,200			
4/13						
4/19						
4/26		3,200				
5/ 3						
5/10						
5/17						
5/24						
5/31	1,600					
6/ 7						
6/16						
6/21						
6/28			12,800			
7/ 5						
7/12		1,600		6,400		
7/19						
7/26		105,792		6,400		
8/ 2		3,200				
8/ 9				6,400		
8/15						
8/23	12,800	3,200	6,400			
8/31					12,800	
9/ 6	12,800	105,792				
9/13						
9/20		423,168				
9/27			12,800			
10/ 4						
10/11	105,792					
10/18		105,792				
10/26	52,896	52,896				
11/ 1		52,896	52,896			
11/ 8					6,400	
11/15						
11/22						
11/30						
12/ 6						
12/14						
12/20						
12/27		52,896				

Table 3.—Organisms per Cubic Meter in Plankton of Smith's Canal in 1913—(*Continued*)

1913	Difflugia pyriformis	Hyalodiscus sp	Microgromia socialis	Trinema enchelys	Total Rhizopoda	Actinophrys sol
1/11						
1/19					3,200	
1/25	800				800	
2/ 2	1,600				1,600	
2/ 8	12,800				12,800	
2/15	22,400				28,800	
2/23	6,400		1,600		11,200	
3/ 1	1,600				4,800	
3/ 8	6,400				11,200	
3/15	79,344		1,600		87,344	
3/23	3,200		1,600		6,400	
3/29					6,400	
4/ 5	12,800				16,000	
4/13	16,000		1,600		17,600	
4/19	211,584		1,600		213,184	
4/26	238,032		105,792		348,624	
5/ 3	79,344				79,344	
5/10	32,000				32,000	
5/17	79,344				79,344	
5/24	140,800				140,800	6,400
5/31	264,480				266,080	
6/ 7	132,240		3,200		138,640	79,344
6/16	105,792				105,792	
6/21	105,792				105,792	12,800
6/28	317,376		1,600		331,776	3,200
7/ 5	238,032				241,232	
7/12	105,792		52,896		220,584	
7/19	3,200		3,200		6,400	
7/26	6,400		3,200		124,992	
8/ 2	6,400		3,200		12,800	
8/ 9	6,400				12,800	
8/15				5,501,184	5,501,184	
8/23			423,168		448,768	
8/31		317,376			647,552	
9/ 6		317,376	1,163,712	105,792	2,022,848	105,792
9/13		105,792	211,584		422,168	
9/20			317,376		740,544	
9/27			105,792		118,592	12,800
10/ 4		211,584	528,960		753,344	211,584
10/11			211,584	105,792	317,376	317,376
10/18			105,792		211,584	
10/26		105,792	264,480		476,064	
11/ 1		52,896	105,792		264,480	
11/ 8		52,896	52,896	105,792	105,792	
11/15					1,600	
11/22						
11/30				1,600		
12/ 6	1,600			1,600	1,600	
12/14	3,200				3,200	
12/20						
12/27				3,200	1,600	

1913	Heterophrys fockei	Nuclearia simplex	Pinaciophora fluviatilis	Raphidiophrys elegans	Total Heliozoa	Ciliate unidentified
1/11						
1/19						
1/25						
2/ 2						1,600
2/ 8						9,600

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Heterophrys fockei	Nuclearia simplex	Pinaciophora fluviatilis	Raphidiophrys elegans	Total Heliozoa	Ciliate unidentified
2/15						1,600
2/23					3,200	1,600
3/ 1						1,600
3/ 8						
3/15						52,896
3/23		1,600				9,600
3/29						
4/ 5						
4/13						12,800
4/19						
4/26				1,600	1,600	
5/ 3				79,344	79,344	
5/10				1,600	1,600	
5/17					25,600	3,200
5/24					6,400	
5/31				41,600	41,600	
6/ 7					79,344	
6/16				1,600	1,600	
6/21					12,800	
6/28				105,792	108,992	
7/ 5				79,344	79,344	
7/12		52,896		264,480	264,480	
7/19	211,584			423,168	634,752	
7/26	211,584			317,376	528,960	
8/ 2	211,584			687,648	899,232	
8/ 9	211,584			105,792	317,376	
8/15						
8/23				1,005,024	1,005,024	
8/31		317,376		211,584	211,584	
9/ 6	105,792	317,376		211,584	423,168	
9/13		105,792				
9/20	423,168				423,168	
9/27	317,376				541,760	
10/ 4	2,962,176	12,800			3,173,760	
10/11	211,584		1,269,504		1,798,464	
10/18	105,792		528,960		634,752	
10/26	52,896		423,168		476,064	
11/ 1			158,688	52,896	211,584	
11/ 8			105,792	687,648	799,840	
11/15			1,600	1,216,608	1,218,208	
11/22						
11/30						
12/ 6						
12/14						
12/20						
12/27		1,600				

1913	Cyclidium sp	Didinium nasutum	Euplotes harpa	Euplotes patella	Halteria grandinella	Hastatella radians
1/11						
1/19						
1/25						
2/ 2						
2/ 8						
2/15			6,400		3,200	
2/23			3,200	9,600	3,200	3,200
3/ 1			3,200			
3/ 8		3,200	3,200			
3/15			9,600	3,200		

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Cyclidium sp	Didinium nasutum	Euplotes harpa	Euplotes patella	Halteria grandinella	Hastatella radians
3/23			28,800			
3/29			6,400	3,200		
4/ 5			3,200			
4/13						
4/19						
4/26					52,896	
5/ 3						
5/10						
5/17						
5/24						
5/31						
6/ 7						
6/16						
6/21						
6/28						
7/ 5						
7/12						
7/19						
7/26						
8/ 2						
8/ 9	3,200					
8/15					3,200	
8/23						
8/31	105,792					
9/ 6						
9/13	105,792					
9/20	105,792					
9/27						
10/ 4						
10/11						
10/18						
10/26						
11/ 1			32,000			
11/ 8			12,800			
11/15		1,600	158,688			
11/22			92,800		3,200	
11/30		3,200	9,600			
12/ 6			41,600			
12/14						
12/20						
12/27						

1913	Holophrya sp	Paramecium aurelia	Paramecium bursaria	Prorodon sp	Stentor coeruleus	Stentor niger
1/11						
1/19						
1/25		1,600			800	
2/ 2						
2/ 8						
2/15						3,200
2/23	1,600			1,600		
3/ 1	3,200					
3/ 8	3,200	3,200				6,400
3/15	3,200					
3/23	3,200			1,600		3,200
3/29						3,200
4/ 5	105,792					
4/13	105,792					
4/19	1,600			1,600		

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Holophrya sp	Paramecium aurelia	Paramecium bursaria	Prorodon sp	Stentor coeruleus	Stentor niger
4/26	52,896				3,200	3,200
5/ 3						3,200
5/10						
5/17	3,200					3,200
5/24	52,896					
5/31	1,600					
6/ 7	1,600					
6/16	1,600					
6/21	1,600					
6/28	1,600					
7/ 5	52,896					
7/12	290,928					
7/19	6,400					
7/26	3,200					
8/ 2	105,792					
8/ 9	211,584					
8/15						
8/23				105,792		
8/31	211,584					
9/ 6	1,904,256					
9/13	423,168					
9/20	211,584					
9/27	12,800					12,800
10/ 4	740,544					
10/11	317,376					
10/18						
10/26						6,400
11/ 1	105,792					
11/ 8	158,688	25,600		52,896		
11/15		16,000	19,200			3,200
11/22	1,600		3,200			
11/30	1,600					
12/ 6	79,344					
12/14	52,896					
12/20	52,896				3,200	3,200
12/27	3,200	1,600		52,896		3,200

1913	Tintinnidium fluviatile	Vorticella longifilum	Vorticella sp	Total Ciliata	Acineta sp	Sphaerophrya sp
1/11						
1/19						
1/25				2,400		
2/ 2				1,600		
2/ 8		1,600		11,200		
2/15				14,400		
2/23		3,200		28,200		
3/ 1				8,000		
3/ 8			6,400	25,600		
3/15		3,200		72,096		
3/23		1,600		48,000		
3/29				12,800		
4/ 5				108,992		
4/13			1,600	120,192		
4/19			1,600	6,400		
4/26			1,600	113,792		
5/ 3			1,600	4,800		
5/10			105,792	105,792		
5/17			158,688	168,288		
5/24		3,200	158,688	214,784		

Table 3 —Organisms Per Cubic Meter in Plankton of Smith's Canal in 1913—(*Continued*)

1913	Tintinnidium fluviatile	Vorticella longifilum	Vorticella sp	Total Ciliata	Acineta sp	Sphaerophrya sp
5/31			238,032	239,632		
6/ 7			211,584	213,184		
6/16			211,584	213,184		
6/21		3,200	449,616	454,416		
6/28		6,400	423,168	440,768		
7/ 5			581,856	634,752		
7/12			793,440	1,084,268		
7/19			581,856	588,256		
7/26			952,128	955,328	105,792	
8/ 2			1,533,984	1,639,776		
8/ 9			952,128	1,166,912	6,400	6,400
8/15				3,200		
8/23			105,792	211,584		
8/31			1,798,464	2,327,424	105,792	
9/ 6			634,752	2,551,808		38,400
9/13	211,584		211,584	952,128		12,800
9/20		105,792	846,336	1,269,504		
9/27	105,792		634,752	804,544		
10/ 4	105,792	12,800	423,168	1,282,304		
10/11			528,960	964,928		64,000
10/18			740,544	740,544		12,800
10/26		25,600	581,856	618,856		6,400
11/ 1	6,400		105,792	249,984		
11/ 8			158,688	408,772		
11/15			52,896	261,184		
11/22		3,200	3,200	108,800		
11/30	1,600		132,240	148,040		
12/ 6		9,600		130,544		3,200
12/14		3,200	1,600	59,296		
12/20			79,344	138,640		
12/27	9,600	1,600	1,600	73,696		

1913	Total Suctoria	Total Protozoa without Mastigophora	Total Protozoa with Mastigophora	Collotheca egg, attached	Collotheca pelagica	Collotheca sp
1/11			1,200			
1/19		3,200	1,070,720			
1/25		3,200	1,545,184			
2/ 2		3,200	1,272,704			
2/ 8		24,000	4,161,840			
2/15		43,200	3,709,024			
2/23		42,600	5,724,776			
3/ 1		12,800	1,042,576			
3/ 8		36,800	504,768			
3/15		159,440	1,071,376			
3/23		54,400	1,879,312			
3/29		19,200	1,316,752			
4/ 5		124,992	290,080			
4/13		137,792	544,864			
4/19		219,584	462,416			
4/26		464,016	1,039,624			
5/ 3		163,488	826,288			
5/10		139,392	469,568			
5/17		273,232	442,424			
5/24		361,984	503,824			
5/31		547,312	712,400			
6/ 7		431,168	858,288			
6/16		320,576	488,016			
6/21		573,008	946,480			
6/28		881,536	1,191,664			

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Total Suctoria	Total Protozoa without Mastigophora	Total Protozoa with Mastigophora	Collotheca egg, attached	Collotheca pelagica	Collotheca sp
7/ 5		955,328	2,293,728			
7/12		1,569,432	3,506,536			
7/19		1,229,408	3,785,920			
7/26	105,792	1,715,072	6,768,992			
8/ 2	44,800	2,596,608	5,222,016			
8/ 9	12,800	1,509,888	5,597,184			
8/15		5,504,384	14,496,704			
8/23		1,665,376	6,329,824	25,600	19,200	
8/31	105,792	3,292,352	7,761,216		12,800	
9/ 6	38,400	5,036,224	11,922,112			
9/13	12,800	1,387,096	6,904,696	51,200	51,200	
9/20		2,433,216	6,254,522	38,400	51,200	
9/27		1,464,896	6,671,504			
10/ 4		5,209,408	11,066,380	105,792	12,800	211,584
10/11	64,000	3,144,768	6,644,704	423,168		153,600
10/18	12,800	1,599,680	4,456,064	25,600	64,000	
10/26	6,400	1,577,384	3,507,240	52,896	105,792	
11/ 1		726,048	4,765,344		12,800	
11/ 8		1,314,404	6,398,820	52,896	52,896	
11/15		1,480,992	4,803,592		3,200	
11/22	3,200	112,000	9,163,520	6,400	3,200	
11/30		148,040	4,094,344			
12/ 6	3,200	135,344	2,849,040			
12/14		62,496	2,935,264			
12/20		138,640	2,459,040			
12/27		75,296	2,703,248			

1913	Total Rhizota	Rotaria neptunia	Rotaria rotatoria	Rotifer egg, winter	Total Bdelloida	Anuraeopsis egg, attached
1/11			1,600		1,600	
1/19			36,800		46,400	
1/25		3,200	19,836		23,036	
2/ 2		1,600	11,200		22,800	
2/ 8			35,200		48,000	
2/15			80,000	6,400	92,800	
2/23		3,200	35,200		44,800	
3/ 1			79,344		98,544	
3/ 8	3,200	3,200	185,136		236,336	
3/15			28,800	3,200	38,400	
3/23		3,200	64,000		68,800	
3/29			60,800		60,800	
4/ 5			16,000		22,400	
4/13			6,400		9,600	
4/19			19,200		20,800	
4/26					6,400	
5/ 3			3,200	6,400	4,800	
5/10			1,600		1,600	
5/17		3,200	12,800		32,000	
5/24				3,200	6,400	
5/31			9,600		168,288	
6/ 7					9,600	
6/16						
6/21			6,400		6,400	
6/28						
7/ 5			6,400	3,200	112,192	
7/12			52,896	6,400	105,792	
7/19					3,200	
7/26				6,400	158,688	
8/ 2		12,800	6,400		177,888	

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Total Rhizota	Rotaria neptunia	Rotaria rotatoria	Rotifer egg, winter	Total Bdelloida	Anuraeopsis egg, attached
8/ 9		32,000	38,400		76,800	
8/15	3,200					
8/23	44,800	12,800	19,200		249,984	
8/31	12,800				25,600	105,792
9/ 6					105,792	
9/13	102,400				211,584	51,200
9/20	89,600		12,800	105,792	224,384	
9/27		12,800	12,800		89,600	
10/ 4	330,176				25,600	
10/11	576,768	12,800			51,200	
10/18	89,600		12,800		12,800	
10/26	158,688	12,800	6,400		72,096	
11/ 1	12,800	52,896	6,400		59,296	
11/ 8	105,792	12,800	6,400	6,400	25,600	
11/15	3,200	3,200	12,800	3,200	16,000	
11/22	9,600	3,200	6,400	52,896	9,600	
11/30			6,400	3,200	6,400	
12/ 6		3,200			3,200	
12/14			3,200		3,200	
12/20						
12/27		6,400	9,600			

1913	Anuraeopsis fissa	Anuraeopsis sp	Asplanchna brightwellii	Brachionus angularis	Brachionus angularis caudatus	Brachionus budapestenensis
1/11						
1/19						
1/25						
2/ 2						
2/ 8						
2/15						
2/23						
3/ 1						
3/ 8				3,200		
3/15			1,600			
3/23				19,200		
3/29						
4/ 5						
4/13						
4/19				22,400		
4/26						
5/ 3				3,200		
5/10				16,000		
5/17				35,200		
5/24				48,000	3,200	
5/31		211,584	3,200	32,000	48,000	
6/ 7				9,600	3,200	9,600
6/16				9,600	3,200	
6/21		1,600		3,200	38,400	
6/28					105,792	
7/ 5				1,600	105,792	
7/12		6,400	3,200	6,400	687,648	
7/19		6,400			57,600	6,400
7/26		6,400			105,792	
8/ 2		3,200			370,272	38,400
8/ 9	105,792				44,800	6,400
8/15						
8/23	6,400			6,400	158,688	6,400
8/31	211,584				740,544	
9/ 6	51,200				317,376	

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Anuraeopsis fissa	Anuraeopsis sp	Asplanchna brightwellii	Brachionus angularis	Brachionus angularis caudatus	Brachionus budapestenensis
9/13	64,000				422,400	12,800
9/20				12,800	25,600	
9/27	317,376		12,800		64,000	
10/ 4	12,800				38,400	38,400
10/11					25,600	
10/18	105,792				211,584	
10/26					6,400	
11/ 1	6,400				19,200	
11/ 8	6,400			6,400		
11/15	1,600					
11/22	52,896		6,400	3,200		
11/30	1,600					
12/ 6						
12/14						
12/20						
12/27						

1913	Brachionus calyciflorus	Brachionus capsuliflorus	Brachionus egg attached, female	Brachionus egg, attached male	Brachionus egg free, female	Brachionus egg, free, male
1/11					1,200	
1/19	6,400			3,200	1,600	
1/25	3,200		1,600	800	1,600	
2/ 2	1,600	1,600			3,200	
2/ 8	38,400		9,600		3,200	
2/15	185,136		238,032	3,200	6,400	
2/23	48,000		28,800		3,200	1,600
3/ 1	6,400		9,600			
3/ 8	38,400		9,600	158,688	9,600	
3/15	9,600				3,200	6,400
3/23	41,600	6,400	22,400		9,600	
3/29	6,400				52,896	
4/ 5	6,400				3,200	
4/13	3,200					
4/19						
4/26	1,600	3,200				
5/ 3	6,400	3,200	9,600		1,600	
5/10			3,200			
5/17	9,600	3,200	12.800	9,600		
5/24		3,200	9,600			
5/31			3,200		52,896	
6/ 7		3,200			6,400	
6/16			12,800		1,600	
6/21			6,400			
6/28	3,200		22,400		1,600	
7/ 5			12,800	6,400		
7/12		52,896	79,344		158,688	
7/19	19,200					
7/26	6,400		25,600		105,792	
8/ 2	105,792	6,400	19,200		12,800	
8/ 9	6,400	317,376	32,000	44,800		
8/15		3,200			158,688	
8/23		6,400			3,200	
8/31	317,376	12,800	76,800		317,376	
9/ 6		12,800	12,800		105,792	
9/13	51,200		64,000		317,376	
9/20	25,600					
9/27	211,584	25,600	51,200		12,800	
10/ 4	211,584	25,600	317,376		211,584	
10/11	204,800		256,000		317,376	

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Brachionus calyciflorus	Brachionus capsuliflorus	Brachionus egg attached, female	Brachionus egg, attached, male	Brachionus egg, free, female	Brachionus egg, free, male
10/18	12,800		105,792			
10/26	32,000				105,792	
11/ 1	12,800		6,400		6,400	
11/ 8	12,800					
11/15	3,200	1,600				
11/22	3,200				132,240	
11/30					3,200	
12/ 6					3,200	
12/14					3,200	
12/20						
12/27					1,600	

1913	Brachionus patulus	Brachionus plicatilis	Brachionus urceus	Diurella egg free	Epiphanes clavulata	Epiphanes egg attached, female
1/11		400				
1/19		1,600				
1/25		2,400	800			
2/ 2			1,600			
2/ 8						
2/15		3,200				
2/23		9,600				
3/ 1			3,200			
3/ 8		12,800				
3/15						
3/23		3,200				
3/29		3,200				
4/ 5		3,200				
4/13						
4/19						
4/26						
5/ 3			3,200			
5/10						
5/17		3,200	3,200	3,200		
5/24				22,400		
5/31				238,032		
6/ 7			3,200			
6/16			9,600	9,600		
6/21			3,200	22,400		
6/28			6,400	105,792		
7/ 5			3,200	6,400		
7/12	6,400		12,800	555,408		
7/19			6,400	158,688		
7/26	19,200		6,400	3,200		
8/ 2	12,800			317,376		
8/ 9	6,400	6,400	12,800	370,272		
8/15						
8/23				740,544	158,688	3,200
8/31			12,800	846,336	76,800	51,200
9/ 6	38,400					
9/13				528,960	128,000	12,800
9/20			38,400	105,792	76,800	38,400
9/27				528,960	12,800	
10/ 4				634,752		
10/11				211,584	25,600	
10/18			12,800	105,792		
10/26			6,400	6,400		
11/ 1					52,896	
11/ 8						
11/15						

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Brachionus patulus	Brachionus plicatilis	Brachionus urceus	Diurella egg, free	Epiphanes clavulata	Epiphanes egg, attached, female
11/22						
11/30						
12/ 6						
12/14						
12/20						
12/27						

1913	Filinia egg attached, female	Filinia egg attached, male	Filinia egg, free	Filinia longiseta	Keratella cochlearis	Keratella egg, attached
1/11				800		400
1/19					4,800	4,800
1/25						2,400
2/ 2					6,400	3,200
2/ 8				3,200	3,200	1,600
2/15				1,600	35,200	19,200
2/23	16,000		6,400	92,800	60,800	16,000
3/ 1	3,200	9,600	9,600	44,800	79,344	9,600
3/ 8		3,200	185,136	60,800	80,000	12,800
3/15			158,688	57,600	317,376	132,240
3/23	22,400			99,200	634,752	370,272
3/29	6,400			32,000	476,064	211,584
4/ 5				3,200	238,032	1,600
4/13				3,200	264,480	52,896
4/19				6,400	502,512	238,032
4/26				1,600	264,480	52,896
5/ 3			79,344	9,600	423,168	185,136
5/10				6,400	83,200	6,400
5/17			1,600	19,200	79,344	3,200
5/24			79,344	3,200	25 600	3,200
5/31					687,648	79,344
6/ 7			9,600	9,600	105,792	
6/16				3,200	32,000	
6/21			158,688	3,200	105,792	3,200
6/28				105,792	264,480	105,792
7/ 5				22,400	449,616	16,000
7/12			132,240	12,800	1,824,912	1,600
7/19					317,376	19,200
7/26				6,400	44,800	25,600
8/ 2			211,584		19,200	
8/ 9			211,584			
8/15					6,400	
8/23			158,688			
8/31			423,168			
9/ 6			105,792		51,200	
9/13						
9/20						
9/27			211,584		25,600	
10/ 4			105,792	12,800		25,600
10/11						211,584
10/18			211,584		1,269,504	105,792
10/26					3,173,760	687,648
11/ 1					4,549,056	1,586,880
11/ 8					793,440	317,376
11/15					317,376	79,344
11/22	3,200		1,600		343,824	238,032
11/30					52,896	19,200
12/ 6					52,896	16,000
12/14					3,200	52,896
12/20						
12/27			1,600			

Table 3.—Organisms Per Cubic Meter in Plankton of Smith's Canal in 1913—(*Continued*)

1913	Keratella egg, free	Keratella quadrata	Notholca striata	Polyarthra trigla	Polyarthra trigla egg attached, female	Synchaeta sp
1/11	2,000	1,600				
1/19	1,600	8,000		3,200		1,600
1/25	19,836	8,000	1,600	19,836		8,000
2/ 2	79,344	6,400	1,600	1,600		1,600
2/ 8	185,136	132,240		211,584		
2/15	185,136	25,600	6,400	132,240		
2/23	12,800	6,400		12,800		6,400
3/ 1		6,400		9,600		9,600
3/ 8		3,200		3,200		156,800
3/15			6,400			3,200
3/23	343,824	79,344		12,800		28,800
3/29	211,584	9,600	1,600	1,600		12,800
4/ 5	52,896	132,240	3,200	6,400		16,000
4/13	79,344	25,600		6,400		6,400
4/19	105,792	19,200	3,200	38,400		22,400
4/26	3,200	28,800		73,600		3,200
5/ 3	158,688	28,800		48,000	3,200	44,800
5/10	22,400	19,200		16,000		3,200
5/17	79,344	105,792		25,600		108,800
5/24				3,200		
5/31	317,376	3,200		76,800		608,304
6/ 7	3,200	6,400		9,600		
6/16						
6/21	52,896	6,400		19,200		3,200
6/28	158,688	185,136		79,344		370,272
7/ 5	264,480	3,200		12,800		35,200
7/12	661,200	79,344		370,272	1,600	52,896
7/19	317,376	19,200		25,600		
7/26	3,200	108,800		51,200		
8/ 2		105,792		211,584		6,400
8/ 9		70,400		105,792		12,800
8/15		44,800		6,400		
8/23		25,600		105,792		6,400
8/31	317,376	12,800		128,000	12,800	211,584
9/ 6		25,600		38,400		38,400
9/13	317, 76	51,200		153,600		12,800
9/20				423,168		
9/27		211,584		89,600		211,584
10/ 4		211,584				
10/11		423,168		12,800		423,168
10/18	211,584	317,376		105,792		211,584
10/26	264,480	158,688	6,400	6,400		264,480
11/ 1	423,168	105,792	12,800			211,584
11/ 8	52,896					370,272
11/15	52,896	3,200				52,896
11/22	132,240	6,400		6,400		105,792
11/30	1,600	6,400		12,800	3,200	105,792
12/ 6		1,600		264,480	3,200	79,344
12/14	6,4 0	79,344		6,400		238,032
12/20	6,400	6,400		6,400		25,600
12/27	3,200	3,200		3,200		185,136

1913	Trichocerca capucina	Trichocerca iernis	Total Ploima	Total Rotifera	Bosmina longirostris	Chydorus sp
1/11			6,800	8,400		
1/19			36,800	83,200		
1/25			71,272	94,308		800
2/ 2			108,144	130,944		
2/ 8			481,520	529,520		

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Trichocerca capucina	Trichocerca iernis	Total Ploima	Total Rotifera	Bosmina longirostris	Chydorus sp
2/15			841,344	934,144		
2/23			324,800	369,600		
3/ 1			200,944	299,488		
3/ 8			737,424	976,960		
3/15			696,304	734,704		
3/23			1,693,792	1,762,592	,200	
3/29			1,025,728	1,086,528		
4/ 5			466,368	488,768		
4/13			441,520	451,120		
4/19			958,336	979,136	6,400	
4/26			432,576	438,976		
5/ 3			1,011,136	1,015,936		
5/10			179,200	180,800		
5/17	6,400		506,080	538,080		
5/24			204,144	210,544		
5/31	3,200	12,800	2,377,584	2,545,872		
6/ 7			179,392	188,992		
6/16			83,200	83,200		
6/21		6,400	434,176	440,576		
6/28	9,600	16,000	1,540,288	1,540,288		
7/ 5	3,200	79,344	1,022,432	1,134,624	3,200	
7/12	3,200	185,136	4,896,784	5,002,576	4,800	
7/19		3,200	959,840	963,040		
7/26	6,400		544,384	703,072	6,400	
8/ 2	6,400	19,200	1,466,400	1,644,288	6,400	
8/ 9		32,000	1,398,816	1,475,616	12,800	
8/15			219,488	219,488	32,000	
8/23		211,584	1,604,384	1,899,178		12,800
8/31		211,584	4,086,720	4,125,120	12,800	
9/ 6		38,400	1,047,744	1,153,536	38,400	
9/13		211,584	2,412,096	2,726,080	38,400	
9/20	12,800	51,200	916,352	1,230,336	51,200	
9/27		740,544	2,727,626	2,817,226	12,800	
10/ 4		423,168	2,269,450	2,625,226	12,800	
10/11		105,792	2,217,472	2,845,440	25,600	
10/18		12,800	3,000,576	3,102,976		
10/26		6 400	4,725,248	4,956,032		
11/ 1			7,006,176	7,078,272		52,896
11/ 8			1,565,984	1,697,376		
11/15			515,312	534,512		
11/22			1,091,520	1,110,720		9,600
11/30			209,888	216,288		
12/ 6			420,720	423,920		
12/14			389,472	392,672		3,200
12/20			44,800	44,800		
12/27			197,936	197,936		

1913	Sida sp	Total Cladocera	Canthocamptus sp	Cyclops sp	Nauplius sp	Total Copepoda
1/11						
1/19				1,600	1,600	3,200
1/25		800			3,200	3,200
2/ 2				3,200	6,400	9,600
2/ 8				3,200	3,200	6,400
2/15			3,200			3,200
2/23					3,200	3,200
3/ 1						
3/ 8						
3/15			3,200			3,200

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Continued*)

1913	Sida sp	Total Cladocera	Cauthocamptus sp	Cyclops sp	Nauplius sp	Total Copepoda
3/23		3,200				
3/29			3,200		1,600	4,800
4/ 5					3,200	3,200
4/13				3,200		3,200
4/19		6,400				
4/26						
5/ 3				3,200	9,600	12,800
5/10				3,200		3,200
5/17						
5/24				3,200	9,600	12,800
5/31	6,400	6,400		3,200	9,600	12,800
6/ 7				3,200	16,000	19,200
6/16				9,600		9,600
6/21				9,600	3,200	16,000
6/28	3,200	3,200			9,600	9,600
7/ 5		3,200		3,200		3,200
7/12	19,600	24,400		24,400	6,400	30,840
7/19	6,400	6,400			6,400	6,400
7/26		6,400		25,600	25,600	51,200
8/ 2	12,800	19,200		12,800	6,400	19,200
8/ 9		12,800		44,800	19,200	64,000
8/15		32,000				32,000
8/23		12,800		6,400	12,800	19,200
8/31	12,800	25,600	12,800	25,600	25,600	64,000
9/ 6		38,400			12,800	12,800
9/13		38,400			25,600	25,600
9/20		51,200				
9/27		12,800	12,800	105,792		118,592
10/ 4		12,800			25,600	25,600
10/11		25,600			12,800	12,800
10/18						
10/26					6,400	6,400
11/ 1	6,400	59,296				
11/ 8						
11/15						
11/22		9,600				
11/30						
12/ 6						
12/14		3,200				
12/20				1,600	1,600	3,200
12/27						

1913	Total Malacostraca	Total Entomostraca	Glochidia	Macrobiotus sp	Nematode sp	Total Miscellaneous	Total Organisms
1/11							1,008,388
1/19	20	3,220			4,800	6,400	10,034,524
1/25		4,000			800	800	6,611,056
2/ 2		9,600		1,600		1,600	9,370,608
2/ 8		6,400			3,200	3,200	18,043,608
2/15		3,200					11,550,608
2/23		3,200					17,982,424
3/ 1							23,079,776
3/ 8					3,200	3,200	12,047,088
3/15		3,200					14,866,400
3/23		3,200			6,400	6,400	19,465,312
3/29		4,800	1,600			1,600	26,761,792
4/ 5		3,200				6,400	6,492,272
4/13		3,200					11,646,736
4/19		6,400		1,600		1,600	13,637,936

TABLE 3.—ORGANISMS PER CUBIC METER IN PLANKTON OF SMITH'S CANAL IN 1913—(*Concluded*)

1913	Total Malacostraca	Total Entomostraca	Glochidia	Macrobiotus sp	Nematode sp	Total Miscellaneous	Total Organisms
4/26							17,044,080
5/ 3		12,800					8,636,424
5/10		3,200					9,321,920
5/17							9,352,280
5/24		12,800					5,949,936
5/31		19,200					5,686,592
6/ 7		19,200					10,101,808
6/16		9,600					15,708,784
6/21		16,000					19,352,112
6/28		12,800					26,840,944
7/ 5		6,400					21,363,952
7/12		55,240	3,200			3,200	40,626,488
7/19		12,800					39,153,568
7/26		57,600	6,400			6,400	61,220,318
8/ 2		38,400		6,400		6,400	66,621,792
8/ 9		76,800	6,400			6,400	114,201,816
8/15		32,000					166,868,542
8/23		32,000	6,400			6,400	141,852,410
8/31		90,600					154,898,534
9/ 6		51,200					254,328,524
9/13		64,000					118,178,940
9/20		51,200					181,305,952
9/27		131,392					129,678,426
10/ 4		38,400					109,717,814
10/11		38,400				105,792	110,191,392
10/18							69,781,440
10/26		6,400					76,617,328
11/ 1		59,296					46,179,728
11/ 8							25,234,116
11/15							13,720,308
11/22		9,600					17,451,856
11/30							12,172,344
12/ 6							16,988,928
12/14		3,200					10,538,544
12/20		3,200					6,416,352
12/27						3,200	7,787,568

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913.

1913	Spirillum undula	Total Bacteriaceae	Anabaena sp.	Aphanacapsa sp	Gloeocapsa conglomerata	Gloeocapsa sp
7/ 5	105,792	105,792		476,064		264,480
7/ 6				952,128		3,200
7/ 7				528,960		370,272
7/ 8			105,792	793,440	528,960	211,584
7/ 9			158,688	687,648	38,400	370,272
7/10			528,960	634,752	846,336	158,688
7/11			528,960	634,752	740,544	476,064
7/12			1,163,712	1,005,024	899,232	581,856
7/13			370,272	1,745,568	1,005,024	476,064
7/14			634,752	1,428,192	581,856	1,639,776
7/15			264,480	1,163,712	899,232	1,586,880
7/16			846,336	1,216,608	158,688	1,375,296
7/17			581,856	793,440		740,544
7/18	3,200	3,200	3,200	211,584		211,584
7/19			581,856	158,688	3,200	528,960
7/20			12,800	3,200		476,064
7/21			3,200	105,792		264,480
7/22			211,584	3,200		264,480
7/23			105,792	6,400		264,480
7/24			6,400	3,200	3,200	158,688
7/25	3,200	3,200	211,584		6,400	317,376
7/26			211,584	264,480		1,005,024
7/27			158,688	264,480	211,584	1,057,920
7/28			211,584	105,792		634,752
7/29			211,584	105,792		793,440
7/30			158,688	211,584	3,200	317,376
7/31			6,400			423,168
8/ 1			105,792	6,400		317,376
8/ 2	3,200	3,200		3,200		105,792
8/ 3			211,584	12,800		634,752
8/ 4			3,200	158,688		105,792

1913	Gomphosphaera aponina	Merismopedium glaucum	Microcystis sp	Nostoc sp	Oscillatoria sp	Oscillatoria tenuis
7/ 5			12,800	793,440		12,800
7/ 6			158,688	320,576		
7/ 7			3,200	743,744		
7/ 8			317,376	1,428,192	105,792	158,688
7/ 9			105,792	687,648	105,792	
7/10				740,544		
7/11			211,584			211,584
7/12			264,480	476,064	3,200	370,272
7/13			264,480	373,472	476,064	3,200
7/14			264,480	793,440	105,792	370,272
7/15	3,200		370,272	1,057,920	870,272	3,200
7/16			317,376	793,440	211,584	
7/17				1,375,296	317,376	1,110,816
7/18			264,480	423,168	370,272	
7/19			264,480	740,544	370,272	
7/20			3,200	214,784	211,584	
7/21	3,200		211,584	317,376	1,269,504	
7/22			3,200	264,480	370,272	105,792
7/23			264,480	171,488	317,376	105,792
7/24			158,688	740,544	158,688	476,064
7/25	3,200		3,200	528,960	370,272	370,272
7/26			264,480	528,960	476,064	
7/27			105,792	330,176	317,376	3,200
7/28	6,400		317,376	746,336	528,960	105,792
7/29		3,200	105,792	581,856	158,688	476,064

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Gomphosphaera aponina	Merismopedium glaucum	Microcystis sp	Nostoc sp	Oscillatoria sp	Oscillatoria tenuis
7/30			211,584	323,776	317,376	
7/31	3,200		317,376	267,680	740,544	317,376
8/ 1			264,480	264,480	317,376	158,688
8/ 2		3,200	105,792	3,200	476,064	3,200
8/ 3		6,400	3,200	581,856	370,272	211,584
8/ 4	3,200		3,200	264,480	476,064	211,584

1913	Phormidium spp	Rivularia sp	Total Schizophyceae	Actinastrum hantzschii	Actinastrum hantzschii (large)	Coelastrum microporum
7/ 5			1,559,584	3,200		6,400
7/ 6	211,584	3,200	1,649,376	3,200		105,792
7/ 7	211,584		1,857,760			158,688
7/ 8			3,649,824			264,480
7/ 9			2,164,240			158,688
7/10	370,272		3,279,552			3,200
7/11			2,803,488			105,792
7/12			4,763,840	6,400	12,800	158,688
7/13			4,723,744			423,168
7/14			5,818,560	3,200	3,200	211,584
7/15			5,719,168		6,400	158,688
7/16			4,919,328		105,792	105,792
7/17			4,919,328		211,584	158,688
7/18			1,484,288		19,200	3,200
7/19			2,648,002		19,200	105,792
7/20			921,632		6,400	105,792
7/21			2,280,928	6,400	105,792	105,792
7/22			1,223,008		105,792	
7/23		6,400	1,262,208		6,400	211,584
7/24			1,705,472		3,200	
7/25			1,811,264		6,400	105,792
7/26			2,750,602	3,200	105,792	476,064
7/27			2,449,216		105,792	158,688
7/28			2,756,992	3,200	19,200	6,400
7/29			2,436,416		211,584	158,688
7/30			1,543,584		6,400	211,584
7/31			2,075,744		3,200	
8/ 1			1,434,592	3,200	12,800	264,480
8/ 2			703,648		6,400	105,792
8/ 3			2,032,448	6,400	19,200	211,584
8/ 4			1,226,208		3,200	211,584

1913	Lagerheimia wratislaviense	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum	Raphidium pyrenogerum
7/ 5			476,064	3,200		
7/ 6			846,336			3,200
7/ 7			528,960			105,792
7/ 8			1,269,504		264,480	370,272
7/ 9		6,400	1,005,024		105,792	3,200
7/10		105,792	793,440			158,688
7/11			1,110,816		3,200	
7/12			1,269,504		3,200	
7/13		105,792	899,232		264,480	
7/14	3,200		793,440		211,584	158,688
7/15			740,544			105,792
7/16			793,440	12,800	105,792	158,688
7/17			1,005,024		6,400	
7/18			634,752		3,200	3,200
7/19		12,800	740,544		3,200	

TABLE 4—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Lagerheimia wratislaviense	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum	Raphidium pyrenogerum
7/20			211,584	6,400		
7/21		12,800	211,584	3,200		3,200
7/22			476,064	12,800		158,688
7/23		6,400	634,752	158,688	3,200	3,200
7/24		105,792	528,960	105,792		105,792
7/25			317,376	19,200	3,200	158,688
7/26		6,400	793,440	19,200	3,200	264,480
7/27	3,200		793,440	6,400	3,200	105,792
7/28			634,752	25,600	6,400	
7/29		19,200	740,544	12,800		
7/30			740,544	3,200		3,200
7/31			528,960	105,792		3,200
8/ 1			423,168	6,400	105,792	158,688
8/ 2		3,200	476,064	6,400		105,792
8/ 3			634,752	12,800	158,688	370,272
8/ 4		6,400	740,544			264,480

1913	Scenedesmus obliquus	Scenedesmus quadricauda	Schroederia setigera	Total Chlorophyceae	Asterionella gracillima	Amphiprora alata
7/ 5	158,688	370,272		1,021,024		3,200
7/ 6	3,200	687,648		1,649,376		
7/ 7	476,064	634,752	3,200	1,907,456	105,792	
7/ 8	370,272	1,163,712		3,702,720		3,200
7/ 9	211,584	634,752		2,131,840		
7/10	370,272	1,057,920		2,489,202		3,200
7/11		1,005,024	3,200	2,228,032		
7/12	211,584	476,064		2,138.232		3,200
7/13	211,584	1,005,024	105,792	3,014,072		3,200
7/14	528,960	1,057,920		2,971,776		3,200
7/15	264,480	264,480	158,688	1,699,072	3,200	
7/16	423,168	1,375,296		3,080,768		
7/17	264,480	899,232	158,688	2,704,096		3,200
7/18	317,376	423,168	264,480	1,668,576		
7/19	528,960	952,128		2,462,624		6,400
7/20	3,200	264,480		597,856		
7/21	158,688	158,688	158,688	819,040		
7/22	476,064	423,168	3,200	1,655,776		3,200
7/23	105,792	581,856	105,792	1,817,664		
7/24	317,376	793,440	3,200	1,963,552		
7/25	211,584	899,232	158,688	1,880,160		
7/26	687,648	1,005,024	105,792	3,470,240		3,200
7/27	740,544	1,692,672	105,792	3,715,520		105,792
7/28	370,272	1,481,088	3,200	2,550,102		6,400
7/29	476,064	687,648		2,306,528		
7/30	317,376	634,752	3,200	1,919,256		3,200
7/31	3,200	581,856	3,200	1,229,408		105,792
8/ 1	634,752	1,005,024	3,200	2,617,504		3,200
8/ 2	105,792	899,232	3,200	1,710,872		
8/ 3	264,480	423,168		2,101,344		
8/ 4	264,480	846,336		2,337,024		

1913	Bacillaria paradoxa	Cyclotella kützingii	Cyclotella operculata	Cymbella affinis	Cymbella cymbiformis	Cymbella tumida
7/ 5		370,272	13,911,648			
7/ 6		740,544	8,780,736			
7/ 7		211,584	11,901,600			
7/ 8		1,005,024	12,906,624			
7/ 9		264,480	12,060,288			
7/10		581,856	13,858,752			

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Bacillaria paradoxa	Cyclotella kützingii	Cyclotella operculata	Cymbella affinis	Cymbella cymbiformis	Cymbella tumida
7/11		370,272	13,118,208			
7/12		211,584	16,556,448			
7/13	12,800	476,064	26,448,000			
7/14	158,688	846,336	37,291,680			
7/15	3,200	634,752	36,022,176			3,200
7/16	12,800	423,168	45,331,872			6,400
7/17	6,400	528,960	46,178,208	12,800		
7/18		317,376	31,949,184			
7/19	57,600	264,480	24,014,784			
7/20	6,400	105,792	14,070,336			
7/21	12,800	105,792	16,133,280			3,200
7/22	6,400	105,792	18,672,288			
7/23		158,688	11,584,224		6,400	
7/24		105,792	13,647,168		3,200	
7/25	6,400	211,584	13,964,544			
7/26	211,584	581,856	16,768,032	3,200		
7/27	51,200	793,440	18,143,328			
7/28		952,128	16,820,928			6,400
7/29		317,376	16,397,760			
7/30		952,128	14,916,672			
7/31	12,800	740,544	17,032,512			
8/ 1	12,800	1,163,712	16,186,176			
8/ 2	32,000	1,692,672	13,224,000			
8/ 3	32,000	1,692,672	12,271,872			
8/ 4	158,688	1,269,504	10,579,200			

1913	Epithemia ocellata	Gyrosigma kutzingii	Gyrosigma scalproides	Melosira granulata	Melosira varians	Navicula alpestris
7/ 5				1,005,024		
7/ 6				1,745,568	3,200	
7/ 7				1,110,816		
7/ 8				1,481,088		3,200
7/ 9				1,481,088		
7/10				1,798,464		
7/11				2,433,216		
7/12				2,697,696		
7/13			3,200	1,269,504	6,400	
7/14				1,533,984		105,792
7/15				1,216,608		
7/16	6,400			1,586,880		
7/17		3,200	3,200	2,486,112	3,200	
7/18				1,957,152	6,400	
7/19				2,168,736		
7/20				476,064		
7/21				1,163,712		
7/22				2,221,632		
7/23				1,428,192		
7/24				3,226,656		
7/25				1,163,712		6,400
7/26				2,962,176		
7/27				2,327,424		
7/28				3,279,552		
7/29		3,200		2,010,048		
7/30				2,539,008		
7/31				1,904,256		
8/ 1				1,163,712		
8/ 2	6,400	25,600		3,914,304		
8/ 3			6,400	4,707,744		6,400
8/ 4			12,800	3,544,032		

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Navicula bacillum	Navicula gracilis	Nitzschia acicularis	Nitzschia sigma	Nitzschia vermicularis	Pleurostauron parvulum
7/ 5	3,200		4,284,576			
7/ 6	3,200	3,200	2,750,592			
7/ 7			4,337,472			
7/ 8		105,792	3,967,200			
7/ 9		3,200	2,909,280			
7/10		158,688	4,760,640	3,200		3,200
7/11		3,200	5,448,288			
7/12	3,200		4,866,432			
7/13		158,688	6,083,040		6,400	
7/14		264,480	5,130,912	3,200		
7/15		105,792	4,496,160	3,200		
7/16	105,792	370,272	5,025,120			
7/17	158,688	370,272	5,183,808	112,192	3,200	
7/18			3,914,304			
7/19		211,584	4,125,888			
7/20		3,200	2,062,944	6,400		
7/21		3,200	2,697,696			
7/22		158,688	2,697,696	3,200		
7/23		3,200	2,380,320			
7/24		105,792	2,909,280	3,200		
7/25		105,792	4,231,680			
7/26		423,168	6,982,272	3,200		
7/27	105,792	476,064	9,309,696	3,200		
7/28		370,272	7,088,064	3,200	6,400	3,200
7/29	3,200	317,376	6,030,144	264,480		3,200
7/30		370,272	3,755,616			
7/31		264,480	4,813,536	19,200		
8/ 1	105,792	211,584	3,544,032			
8/ 2	3,200	264,480	3,385,344	6,400		
8/ 3	3,200	3,200	3,226,656			
8/ 4	3,200	317,376	3,702,720		6,400	

1913	Surirella sp	Synedra radians	Synedra ulna	Total Bacillariaceae	Closterium rostratum	Mougeotia sp
7/ 5			423,168	20,001,088		
7/ 6			370,272	14,397,312		
7/ 7			952,128	18,619,392		
7/ 8			899,232	20,374,560		
7/ 9	6,400		476,064	17,204,000		
7/10			581,856	21,749,856		
7/11			370,272	21,743,456		3,200
7/12			423,168	24,761,728		3,200
7/13		5,501,184	740,544	40,709,024		3,200
7/14		5,765,664	637,952	51,741,888	3,200	317,376
7/15	3,200	4,284,576	846,336	47,625,600	3,200	
7/16	3,200	4,496,160	634,752	58,002,816		3,200
7/17	19,200	3,279,552	1,110,816	59,463,008		3,200
7/18	6,400	1,322,400	317,376	39,790,592		
7/19		634,752	317,376	31,801,600		
7/20	12,800	528,960	264,480	17,543,776		6,400
7/21	3,200	528,960	476,064	21,127,904		
7/22	12,800	793,440	370,272	25,045,408		
7/23	3,200	581,856	528,960	16,675,040		3,200
7/24	12,800	370,272	476,064	20,863,424		
7/25	6,400	476,064	211,584	20,387,360	3,200	105,792
7/26	105,792	899,232	687,648	29,637,760		
7/27	12,800	687,648	793,440	32,809,824		158,688
7/28	6,400	476,064	899,232	29,918,240		3,200
7/29	12,800	1,005,024	899,232	27,263,840	3,200	3,200

TABLE 4—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Surirella sp	Synedra radians	Synedra ulna	Total Bacillariaceae	Closterium rostratum	Mougeotia sp
7/30	6,400	423,168	528,960	23,495,424	3,200	
7/31	6,400	476,064	370,272	25,745,856	6,400	
8/ 1	105,792	846,336	423,168	23,766,304	3,200	
8/ 2		370,272	423,168	23,354,240		
8/ 3	12,800	370,272	634,752	22,967,968		
8/ 4	25,600	793,440	211,584	20,630,944	3,200	105,792

1913	Staurastrum *A*	Staurastrum sp	Total Conjugatae	Total Chlorophyll bearing	Total Algae	Cercomonas crassicauda
7/ 5	3,200		6,400	24,657,440	22,693,888	
7/ 6		3,200	3,200	20,518,752	17,699,264	
7/ 7				25,811,552	22,384,608	
7/ 8				31,487,424	27,727,104	
7/ 9	6,400		6,400	24,516,656	21,506,480	
7/10		3,200	3,200	31,763,090	27,521,810	
7/11			3,200	30,378,304	26,778,176	
7/12			3,200	37,862,232	31,667,000	
7/13			3,200	56,860,504	48,450,040	
7/14			320,576	68,840,096	60,852,800	
7/15			3,200	62,240,896	55,047,040	
7/16	6,400		9,600	71,364,608	66,012,512	3,200
7/17			3,200	72,392,032	67,089,632	
7/18	3,200	3,200	6,400	48,292,352	42,953,056	
7/19				43,953,794	36,912,226	
7/20			6,400	22,560,800	19,069,664	
7/21				27,722,208	24,227,872	
7/22	6,400		6,400	30,423,104	27,930,592	
7/23			3,200	23,044,054	19,758,112	
7/24	3,200	3,200	6,400	27,956,192	24,538,848	
7/25			108,992	27,893,696	24,190,976	
7/26		3,200	6,400	44,063,882	35,865,002	
7/27			158,688	45,490,368	39,133,248	
7/28	6,400		9,600	42,223,606	35,234,934	
7/29	6,400		12,800	39,375,328	32,019,584	
7/30			9,600	31,213,344	26,967,864	3,200
7/31			6.400	33,447,776	29,057,408	
8/ 1			3,200	34,225,216	27,821,600	
8/ 2				30,601,496	25,771,960	
8/ 3		3,200	3,200	32,774,432	27,104,960	
8/ 4	6,400	3,200	118,592	31,681,322	24,312.778	

1913	Chilomonas sp	Chlamydomonas sp	Chromulina sp	Eudorina elegans	Euglena viridis	Hemidinium nasutum
7/ 5			634,752		3,200	
7/ 6			1,428,192	6,400		
7/ 7			2,221,632	6,400	3,200	
7/ 8			3,385,344	57,600	105,792	
7/ 9			2,486,112	19,200	211,584	
7/10			3,596,928	3,200	3,200	
7/11			3,120,864	3,200	105,792	
7/12			4,919,328	6,400	793,440	
7/13			6,664,896		1,057,920	
7/14			7,088,064	158,688	370,272	
7/15			6,188,932		634,752	
7/16			5,183,808	6,400	158,688	
7/17			4,866,432	6,400	423,168	
7/18		105,792	4,760,640		476,064	
7/19		05,792	6,929,376		6,400	

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Chilomonas sp	Chlamydomonas sp	Chromulina sp	Eudorina elegans	Euglena viridis	Hemidinium nasutum
7/20			3,015,072		476,064	
7/21			2,856,384		634,752	
7/22			2,274,528	3,200	211,584	
7/23			3,173,760		105,792	
7/24			2,750,592		476,064	
7/25			2,803,488		423,168	
7/26			7,299,648		370,272	
7/27			5,395,392	6,400	634,752	
7/28			6,347,520		423,168	
7/29			4,496,160		423,168	2,327,424
7/30			3,279,552	6,400	423,168	528,960
7/31			3,385,344		158,688	846,336
8/ 1	3,200		3,649,824		264,480	2,486,112
8/ 2			3,967,200		105,792	634,752
8/ 3	3,200		4,919,328		3,200	634,752
8/ 4		3,200	5,130,912		12,800	1,639,776

1913	Mallomonas sp	Peridinium cinctum	Pleodorina californica	Pteromonas sp	Synura uvella	Trachelomona euchlora
7/ 5	3,200	1,005,024		158,688		
7/ 6		581,856	6,400	211,584	158,688	
7/ 7		634,752		32,000		
7/ 8						
7/ 9		3,200		32,000		
7/10		105,792				
7/11						
7/12						
7/13						
7/14		264,480				
7/15						
7/16						
7/17	3,200					
7/18						
7/19						
7/20						
7/21						
7/22						
7/23						3,200
7/24				32,000		
7/25		317,376		3,200		
7/26		317,376		105,792		
7/27		105,792		3,200		
7/28		6,400				
7/29		105,792				
7/30		3,200				
7/31						
8/ 1						
8/ 2			6,400		3,200	3,200
8/ 3						
8/ 4						211,584

1913	Trachelomonas volvocina	Total Mastigophora	Amoeba radiosa	Difflugia pyriformis	Microgromia socialis	Total Rhisopoda
7/ 5	264,480	2,069,344		211,584		224,384
7/ 6	317,376	2,819,488	3,200	476,064		479,264
7/ 7	528,960	3,426,944		264,480	3,200	267,680
7/ 8	211,584	3,760,320	3,200	12,800		19,200
7/ 9	264,480	3,016,576		264,480		270,880
7/10	528,960	4,241,280		3,200		3,200

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Trachelomonas volvocina	Total Mastigophora	Amoeba radiosa	Difflugia pyriformis	Microgromia socialis	Total Rhizopoda
7/11	370,272	3,600,128				
7/12	476,064	6,195,232				3 200
7/13	687,648	8,410,464				3,200
7/14	105,792	7,987,296			3,200	6,400
7/15	370,272	7,193,856				3,200
7/16		5,352,096			3,200	112,192
7/17		5,302,400		6,400		12,800
7/18		5,342,496		6,400		9,600
7/19		7,041,568		3,200		6,400
7/20		3,491,136		105,792		108,992
7/21	3,200	3,494,336		6,400		6,400
7/22		2,492,512				
7/23	3,200	3,285,952			105,792	105,792
7/24	158,688	3,417,344		105,792	105,792	370,272
7/25	158,688	3,705,920		158,688		158,688
7/26	105,792	8,198,880		264,480		267,680
7/27	211,584	6,357,120		211,584	3 200	217,984
7/28	211,584	6,988,672		6,400	3,200	12,800
7/29	3,200	7,355,744		105,792		211,584
7/30		4,244,480			3,200	3,200
7/31		4,390,368		3,200		6,400
8/ 1		6,403,616				
8/ 2	105,792	4,832,736				
8/ 3	105,792	5,669,472			158,688	158,688
8/ 4	370,272	7,368,544			105,792	105,792

1913	Heterophrys fockei	Raphidiophrys elegans	Total Heliozoa	Holophrya sp	Prorodon sp	Tintinnidium fluviatile
7/ 5		528,960	528,960	158,688		
7/ 6		740,544	740,544	105,792		
7/ 7		846,336	846,336	158,688		
7/ 8		1,110,816	1,110,816	105,792		
7/ 9		846,336	846,336	211,584		
7/10		370,272	370,272	211,584		
7/11		423,168	423,168	423,168		
7/12		158,688	158,688	3,200		
7/13		1,110,816	1,110,816	211,584		
7/14		1,005,024	1,005,024	105,792		
7/15		370,272	370,272	528,960		
7/16		528,960	528,960	6,400		
7/17		158,688	158,688			
7/18		211,584	211,584			
7/19		370,272	370,272			
7/20	6,400	105,792	112,192	3,200		
7/21	105,792	264,480	310,272	264,480		
7/22		317,376	317,376	3,200		
7/23		317,376	317,376			
7/24		317,376	317,376	3,200	3,200	
7/25		105,792	105,792	264,480		
7 26		370,272	370,272	211,584		
7/27		476,064	476,064	317,376		
7/28	105,792	423,168	528,960	158,688		
7/29		528,960	528,960	158,688		
7/30	44,800	370,272	415,072	105,792		105,792
7/31	105,792	476,064	581,856	105,792	3,200	105,792
8/ 1	6,400	687,648	694,048	264,480		3,200
8/ 2	528,960	1,269,504	1,798,464	105,792		
8/ 3	528,960	740,544	1,269,504	3,200		6,400
8/ 4	317,376	952,128	1,269,504	158,688		6,400

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Vorticella *B*	Vorticella longifilum	Vorticella sp.	Total Ciliata	Total, Protozoa without Mastigophora	Total, Protozoa with Mastigophora
7/ 5	3,200	....	2,644,800	2,806,688	3,560,032	5,629,376
7/ 6	....	....	1,375,296	1,490,688	2,707,496	5,526,984
7/ 7	158,688	....	1,057,920	1,216,608	2,330,624	5,757,568
7/ 8	211,584	....	1,110,816	1,216,608	2,346,624	6,106,944
7/ 9	370,272	....	476,064	687,648	1,804,864	4,821,440
7/10	634,752	....	1,322,400	1,533,984	1,907,456	6,148,736
7/11	105,792	....	846,336	1,269,504	1,692,672	5,292,800
7/12	158,688	....	740,544	743,744	905,632	7,100,864
7/13	....	....	634,752	846,336	1,960,352	10,370,816
7/14	105,792	....	1,163,712	1,269,504	2,280,928	10,268,224
7/15	....	....	846,336	1,375,296	1,748,768	8,942,624
7/16	3,200	....	1,110,816	1,116,216	1,757,368	7,109,464
7/17	....	....	1,163,712	1,163,712	1,335,200	6,637,600
7/18	....	....	370,272	370,272	591,456	5,933,952
7/19	....	....	1,057,920	1,057,920	1,434,592	8,476,160
7/20	....	....	476,064	476,064	697,448	4,188,584
7/21	....	....	370,272	634,752	951,424	4,445,760
7/22	....	....	1,005,024	1,008,224	1,325,600	3,818,112
7/23	....	....	476,064	476,064	899,232	4,185,184
7/24	....	....	899,232	905,632	1,593,280	5,010,624
7/25	....	....	793,440	1,163,712	1,428,192	5,134,112
7/26	....	....	1,269,504	1,487,488	2,125,440	10,324,320
7/27	....	....	1,957,152	2,274,528	2,968,576	9,325,696
7/28	....	....	1,586,880	1,745,568	2,287,328	9,276,000
7/29	476,064	3,200	2,010,048	2,171,936	2,912,480	10,268,224
7/30	....	6,400	899,232	1,117,216	1,535,488	5,779,968
7/31	....	....	1,533,984	1,748,768	2,337,024	6,727,392
8/ 1	....	....	1,269,504	1,537,184	2,231,232	8,634,848
8/ 2	....	....	1,639,776	1,748,768	3,547,232	8,379,968
8/ 3	....	....	1,957,152	1,966,752	4,394,944	10,064,416
8/ 4	....	3,200	1,692,672	1,860,950	4,236,246	11,604,790

1913	Rotaria neptunia	Rotaria rotatoria	Rotifer unidentified	Total Bdelloida	Anuraeopsis fissa	Asplanchua brightwelli
7/ 5	....	19,200	158,688	177,888	....	158,688
7/ 6	....	25,600	211,584	237,184	....	57,600
7/ 7	6,400	6,400	3,200	16,000	3,200	70,400
7/ 8	....	12,800	6,400	19,200	6,400	19,200
7/ 9	....	6,400	3,200	9,600	....	19,200
7/10	....	25,600	....	25,600	6,400	89,600
7/11	12,800	3,200	....	16,000	....	51,200
7/12	....	211,584	3,200	214,784	....	44,800
7/13	....	38,400	158,688	196,088	3,200	76,800
7/14	3,200	264,480	158,688	426,368	3,200	158,688
7/15	....	6,400	3,200	9,600	....	64,000
7/16	....	19,200	19,200	38,400	....	12,800
7/17	....	317,376	264,480	581,856	....	19,200
7/18	....	6,400	3,200	9,600	....	105,792
7/19	....	....	158,688	158,688	....	6,400
7/20	....	6,400	3,200	9,600	6,400	12,800
7/21	....	19,200	....	19,200	6,400	19,200
7/22	....	19,200	3,200	22,400	....	25,600
7/23	....	317,376	....	317,376	6,400	3,200
7/24	6,400	105,792	3,200	115,392	,200	12,800
7/25	....	6,400	105,792	112,192	....	....
7/26	....	12,800	25,600	38,400	....	19,200
7/27	19,200	6,400	105,792	131,392	19,200	38,400
7/28	....	....	211,584	211,584	6,400	12,800
7/29	....	....	105,792	105,792	....	32,000

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Rotaria neptunia	Rotaria rotatoria	Rotifer unidentified	Total Bdelloida	Anuraeopsis fissa	Asplanchna brightwelli
7/30	6,400	6,400	3,200	16,000		25,600
7/31	6,400	12,800		19,200	6,400	
8/ 1		3,200	158,688	161,888		18,200
8/ 2		32,000	3,200	41,600		44,800
8/ 3		158,688	3,200	174,688		105,792
8/ 4		6,400	105,792	112,192		12,800

1913	Brachionus angularis	Brachionus angularis caudatus	Brachionus budapestenensis	Brachionus calyciflorus	Brachionus capsuliflorus	Brachionus egg, attached, female
7/ 5	3,200	476,064				158,688
7/ 6	3,200	423,168				105,792
7/ 7	3,200	264,480				105,792
7/ 8		1,269,504				528,960
7/ 9		1,163,712		3,200		687,648
7/10		581,856		6,400		264,480
7/11		1,005,024				317,376
7/12	158,688	1,375,296				528,960
7/13		581,856				317,376
7/14		846,336				687,648
7/15	3,200	740,544				423,168
7/16		793,440				846,336
7/17		1,057,920			19,200	264,480
7/18		1,110,816				370,272
7/19		793,440				476,064
7/20	6,400	476,064				158,688
7/21		370,272	6,400			211,584
7/22	158,688	528,960				581,856
7/23		317,376			6,400	158,688
7/24	3,200	740,544	6,400			476,064
7/25		1,216,608				846,336
7/26		1,481,088		6,400		370,272
7/27	105,792	3,755,616				1,428,192
7/28		1,851,360				634,752
7/29		581,856				211,584
7/30		423,168			6,400	12,800
7/31		264,480			6,400	211,584
8/ 1		581,856				370,272
8/ 2		211,584				264,480
8/ 3		211,584			6,400	105,792
8/ 4	6,400	264,480				158,688

1913	Brachionus egg, attached, male	Brachionus egg free, female	Brachionus patulus	Brachionus plicatilis	Brachionus urceus	Diurella egg
7/ 5		1,005,024		6,400	44,800	
7/ 6		581,856			6,400	3,200
7/ 7		793,440			12,800	3,200
7/ 8	105,792	1,057,920			19,200	
7/ 9		899,232			44,800	3,200
7/10		1,269,504			211,584	3,200
7/11		846,336			158,688	
7/12		1,005,024	6,400		528,960	
7/13		740,544			370,272	
7/14		528,960			581,856	
7/15		687,648			528,960	
7/16		370,272			528,960	
7/17		476,064			47,064	
7/18		1,005,024			1,216,608	

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Brachionus egg, attached, male	Brachionus egg, free, female	Brachionus patulus	Brachionus plicatilis	Brachionus urceus	Diurella egg
7/19		264,480			370,272	
7/20		423,168			740,544	
7/21		846,336			634,752	
7/22		1,057,920			634,752	
7/23		740,544			6,400	
7/24		528,960			211,584	
7/25		1,057,920			370,272	
7/26		476,064			423,168	
7/27		1,851,360			528,960	
7/28		528,960			528,960	6,400
7/29		952,128	3,200		370,272	
7/30		423,168			105,792	
7/31		423,168			158,688	
8/ 1		528,960			423,168	6,400
8/ 2		423,168			370,272	105,792
8/ 3		158,688			423,168	6,400
8/ 4	25,600	317,376		6,400	317,376	

1913	Filinia brachiata	Filinia egg, attached, female	Filinia egg, free	Filinia longiseta	Keratella cochlearis	Keratella egg, attached
7/ 5	3,200	158,688	370,272	1,375,296	793,440	211,584
7/ 6		105,792	528,960	370,272	211,584	
7/ 7	3,200	105,792	317,376	317,376	476,064	3,200
7/ 8		3,200	528,960	264,480	211,584	3,200
7/ 9		3,200	476,064	12,800	211,584	3,200
7/10			476,064	44,800	423,168	105,792
7/11		6,400	423,168	158,688	581,856	3,200
7/12			370,272	105,792	423,168	3,200
7/13			3,200	158,688	476,064	105,792
7/14		3,200	105,792	211,584	476,064	3,200
7/15			158,688		158,688	3,200
7/16				25,600	12,800	105,792
7/17			105,792	25,600	32,000	
7/18			211,584		25,600	
7/19		6,400	105,792	6,400	32,000	211,584
7/20			105,792	19,200	158,688	
7/21			3,200	6,400	158,688	3,200
7/22			105,792	6,400	105,792	317,376
7/23			105,792		38,400	211,584
7/24			158,688		19,200	264,480
7/25			211,584		12,800	264,480
7/26			211,584		6,400	264,480
7/27			105,792			423,168
7/28			158,688		6,400	264,480
7/29			105,792		19,200	687,648
7/30			158,688		12,800	105,792
7/31			158,688		3,200	317,376
8/ 1						158,688
8/ 2						158,688
8/ 3			211,584		12,800	3,200
8/ 4			158,688			158,688

1913	Keratella egg, free	Keratella quadrata	Polyarthra trigla	Polyarthra trigla egg, attached	Synchaeta sp	Trichocerca capucina
7/ 5	476,064	1,163,712	158,688		528,960	
7/ 6	264,480	317,376	211,584		19,200	
7/ 7	105,792	317,376	528,960			
7/ 8	158,688	687,648	740,544			
7/ 9	211,584	264,480	899,232	3,200	12,800	3,200

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Continued*)

1913	Keratella egg, free	Keratella quadrata	Polyarthra trigla	Polyarthra trigla egg, attached	Synchaeta sp	Trichocerca capucina
7/10	317,376	528,960	1,745,568			
7/11	370,272	687,648	1,798,464			
7/12	687,648	1,322,400	1,692,672	3,200	3,200	3,200
7/13		1,110,816	1,904,256			
7/14	3,200	1,057,920	1,163,712			
7/15		1,110,816	370,272		3,200	
7/16		952,128	687,648		6,400	
7/17	211,584	687,648	38,400			3,200
7/18	105,792	1,322,400	76,800			
7/19	105,792	846,336	158,688			
7/20	105,792	1,057,920	89,600			
7/21	158,688	846,336	158,688			
7/22	211,584	1,110,816	101,400		12,800	
7/23		1,692,672	134,400		6,400	
7/24	105,792	1,163,712	211,584		3,200	
7/25	3,200	2,010,048	476,064			
7/26		2,062,944	634,752			
7/27	158,688	5,554,080	1,216,608	3,200	6,400	
7/28	3,200	2,644,800	581,856		6,400	
7/29	3,200	4,601,952	846,336	3,200		3,200
7/30	3,200	2,010,048	952,128			
7/31	105,792	2,856,384	846,336		6,400	
8/ 1		2,909,280	793,440			
8/ 2	105,792	1,110,816	793,440	3,200		
8/ 3		423,168	264,480	6,400		
8/ 4		1,057,920	264,480			

1913	Trichocerca iernis	Total Ploima	Total Rotifera	Bosmina longirostris	Sida	Total Cladocera
7/ 5	19,200	7,111,968	7,289,956		6,400	6,400
7/ 6	19,200	3,229,664	3,466,848		32,000	32,000
7/ 7	158,688	3,590,336	3,606,336		6,400	6,400
7/ 8	317,376	5,921,656	5,940,856			
7/ 9	211,584	5,127,720	5,137,320			
7/10	370,272	6,445,024	6,470,624		6,400	6,400
7/11	476,064	6,884,384	6,900,384		12,800	12,800
7/12	317,376	8,578,056	8,792,840		6,400	6,400
7/13	264,480	6,113,344	6,309,432		12,800	12,800
7/14	105,792	5,940,352	6,367,720			
7/15		4,252,384	4,261,984		6,400	6,400
7/16	6,400	4,348,576	4,386,976			
7/17	3,200	3,419,552	4,001,408	6,400	6,400	12,800
7/18	6,400	5,557,088	5,566,688		12,800	12,800
7/19	6,400	3,390,048	3,548,736		12,800	12,800
7/20	12,800	3,373,856	3,383,456	12,800		12,800
7/21	158,688	3,588,832	3,608,032			
7/22	6,400	4,966,136	4,988,536	12,800	12,800	25,600
7/23		3,428,256	3,745,632			
7/24		3,010,176	3,125,568		12,800	12,800
7/25	158,688	6,069,000	6,181,192		6,400	6,400
7/26	12,800	5,972,352	6,010,752		6,400	6,400
7/27	3,200	15,098,656	15,230,048		6,400	6,400
7/28	6,400	7,241,956	7,453,440			
7/29	6,400	8,434,368	8,540,160			
7/30	19,200	4,255,784	4,271,784	6,400		6,400
7/31	25,600	5,384,096	5,403,296			
8/ 1	25,600	5,816,864	5,978,752			
8/ 2	19,200	3,639,032	3,680,632	6,400	6,400	12,800
8/ 3	12,800	1,958,656	2,133,344	6,400		6,400
8/ 4	6,400	2,859,088	2,971,280		6,400	6,400

TABLE 4.—PLANKTON ORGANISMS PER CUBIC METER IN STOCKTON CHANNEL, DAILY SERIES IN 1913—(*Concluded*)

1913	Cyclops	Nauplius	Total Copepoda	Total Entomostraca	Glochidia	Total Organisms
7/ 5	268,800	1,057,920	1,326,720	1,333,120	....	36,946,240
7/ 6	332,800	634,752	967,552	999,552	....	27,692,648
7/ 7	317,376	528,960	846,336	852,736	....	32,601,248
7/ 8	317,376	793,440	1,110,816	1,110,816	....	40,885,720
7/ 9	370,272	1,163,712	1,533,984	1,533,984	....	32,992,824
7/10	230,400	793,440	1,023,840	1,030,240	....	41,171,410
7/11	358,400	740,544	1,098,944	1,111,744	....	40,083,104
7/12	740,544	856,336	1,586,880	1,593,280	....	49,153,984
7/13	268,800	1,375,296	1,644,096	1,656,896	....	66,787,184
7/14	687,648	1,428,192	2,115,840	2,115,840	....	79,604,584
7/15	476,064	1,057,920	1,533,984	1,540,384	....	69,792,032
7/16	454,400	793,440	1,247,840	1,247,840	....	78,756,792
7/17	264,480	740,544	1,005,024	1,017,824	....	78,746,464
7/18	581,856	581,856	1,163,712	1,176,512	....	55,630,208
7/19	687,648	740,544	1,428,192	1,440,992	6,400	50,284,514
7/20	581,856	899,232	1,481,088	1,493,888	....	28,135,592
7/21	581,856	1,745,568	2,327,424	2,327,424	....	34,609,088
7/22	3,173,760	1,692,672	4,866,432	4,892,032	3,200	41,632,472
7/23	264,480	1,110,816	1,375,296	1,375,296	....	29,064,214
7/24	264,480	899,232	1,170,112	1,182,912	....	33,857,952
7/25	423,168	952,128	1,375,296	1,381,696	....	36,887,976
7/26	264,480	687,648	952,128	958,528	....	53,158,602
7/27	476,064	952,128	1,428,192	1,434,592	....	65,123,584
7/28	528,960	793,440	1,322,400	1,322,400	....	53,286,774
7/29	634,752	1,269,504	1,904,256	1,904,256	3,200	52,735,424
7/30	317,376	740,544	1,057,920	1,064,320	3,200	38,088,136
7/31	423,168	581,856	1,005,024	1,005,024	6,400	42,199,520
8/ 1	846,336	899,232	1,745,568	1,745,568	....	44,180,768
8/ 2	581,856	1,322,400	1,904,256	1,917,056	....	39,749,616
8/ 3	264,480	846,336	1,110,816	1,117,216	....	40,419,936
8/ 4	317,376	1,163,712	1,481,088	1,487,488	....	40,376,336

TABLE 5.—PLANKTON ORGANISMS PER CUBIC METER IN SMITH'S CANAL, HOURLY SERIES IN 1913

1913 8/11	Lamprocystis sp	Total Bacteriaceae	Anabaena sp	Aphanocapsa sp	Coelosphaerium kutzingianum	Gloeocapsa conglomerata
7 A.M.			105,792	264,480		52,896
8 A.M.			343,824	158,688		6,400
9 A.M.			52,896	6,400		
10 A.M.			396,720	52,896		105,792
11 A.M.			449,616	211,584	52,896	52,896
12 M.			449,616	343,824		6,400
1 P.M.			502,512	158,688		105,792
2 P.M.			1,163,712	105,792		52,896
3 P.M.			1,719,120	502,512		52,896
4 P.M.	52,896	52,896	1,666,224	211,584		52,896
5 P.M.	52,896	52,896	3,861,408	158,688		
5:48 P.M.			3,967,200	105,792		
6:40 P.M.	6,400	6,400	5,236,704	158,688	52,896	158,688

1913 8/11	Gloeocapsa sp	Gomphosphaera aponina	Microcystis sp	Nostoc sp	Oscillatoria sp	Oscillatoria tenuis
7 A.M.	343,824	52,896	211,584	211,584		
8 A.M.	343,824		343,824	52,896		
9 A.M.	264,480		449,616	52,896		
10 A.M.	343,824		158,688	396,720		
11 A.M.	343,824		105,792	105,792	158,688	
12 M	158,688	158,688	661,200	459,616		
1 P.M.	766,992		264,480	52,896		
2 P.M.	661,200	158,688	343,824	3,120,864		
3 P.M.	608,304		343,824	4,522,608		105,792
4 P.M.	608,304		396,720	5,448,288		52,896
5 P.M.	925,680		502,512	3,914,304	449,616	
5:48 P.M.	714,096		502,512	2,697,696	502,512	
6:40 P.M.	925,680	105,792	449,616	3,306,000	264,480	

1913 8/11	Phormidium foveolarum	Stigonema ocellatum	Total Schizophyceae	Actinastrum hantzschii	Actinastrum hantzschii (large)	Coelastrum microporum
7 A.M.	211,584		1,454,644		105,792	105,792
8 A.M.	158,688	52,896	1,461,040		158,688	105,792
9 A.M.	158,688		984,976		264,480	105,792
10 A.M.			1,454,640		343,824	52,896
11 A.M.	52,896		1,533,984	52,896	502,512	105,792
12 M.	264,480	52,896	2,545,408	6,400	211,584	158,688
1 P.M.	264,480		2,115,840	52,896	449,616	52,896
2 P.M.	343,824		5,871,456	52,896	343,824	6,400
3 P.M.	211,584		8,096,640	52,896	661,200	19,200
4 P.M.	264,480		8,701,394	52,896	264,480	158,688
5 P.M.	264,480	6,400	10,083,088		396,720	52,896
5:48 P.M.		52,896	8,542,704	52,896	502,512	211,584
6:40 P.M.			12,040,250	6,400	608,304	264,480

1913 8/11	Pediastrum boryanum	Pediastrum duplex	Pediastrum simplex	Raphidium polymorphum	Raphidium pyrenogerum	Scenedesmus obliquus
7 A.M.		449,616	6,400			52,896
8 A.M.	12,800	766,992	52,896			264,480
9 A.M.		396,720				52,896
10 A.M.		449,616	105,792			211,584
11 A.M.		661,200	158,688			52,896
12 M.	12,800	608,304	52,896			
1 P.M.	52,896	1,216,608	6,400		52,896	52,896
2 P.M.	19,200	1,163,712	52,896	105,792		343,824
3 P.M.	12,800	1,110,816	105,792	52,896		343,824
4 P.M.	105,792	925,680	52,896	6,400		211,584
5 P.M.	158,688	1,533,984	12,800			264,480
5:48 P.M.	105,792	1,481,088	25,600			158,688
6:40 P.M.	6,400	1,216,608	6,400	52,896	105,792	158,688

TABLE 5.—PLANKTON ORGANISMS PER CUBIC METER IN SMITH'S CANAL, HOURLY SERIES IN 1913—(*Continued*)

1913 8/11	Scenedesmus quadricauda	Schroederia setigera	Total Chlorophyceae	Asterionella gracillima	Amphiprora alata	Bacillaria paradoxa
7 A.M.	158,688	....	673,392	52,896	158,688	264,480
8 A.M.	264,480	....	1,467,440	....	264,480	211,584
9 A.M.	105,792	....	661,200	52,896	502,512	158,688
10 A.M.	211,584	....	1,031,472	....	502,512	211,584
11 A.M.	264,480	105,792	1,295,952	....	502,512	60,800
12 M.	158,688	....	997,776	....	211,584	343,824
1 P.M.	264,480	....	1,751,968	....	343,824	211,584
2 P.M.	449,616	....	2,194,336	....	211,584	396,720
3 P.M.	449,616	....	2,147,840	....	211,584	449,616
4 P.M.	396,720	....	1,910,656	52,896	105,792	343,824
5 P.M.	555,408	....	2,578,256	....	52,896	158,688
5:48 P.M.	588,408	105,792	2,696,848	....	158,688	343,824
6:40 P.M.	925,680	....	2,743,334	....	264,480	158,688

1913 9/11	Cyclotella kützingii	Cyclotella operculata	Cymbella affinis	Cymbella cymbiformis	Cymbella tumida	Epithemia ocellata
7 A.M.	1,428,192	3,808,572	....	....	....	52,896
8 A.M.	1,005,024	4,311,024	....	6,400	52,896	....
9 A.M.	1,322,400	4,178,784	....	....	....	6,400
10 A.M.	1,666,224	3,464,688	....	....	....	....
11 A.M.	1,269,504	2,750,592	....	52,896	....	....
12 M.	819,888	2,697,696	52,896	....	....	....
1 P.M.	1,719,120	3,623,376	....	....	....	....
2 P.M.	1,983,600	4,178,784	52,896	....	6,400	....
3 P.M.	2,195,184	2,856,384	52,896	....	....	....
4 P.M.	2,036,496	3,702,720	105,792	....	....	....
5 P.M.	2,539,008	4,072,992	....	....	12,800	....
5:48 P.M.	1,877,808	4,072,992	....	....	....	....
6:40 P.M.	1,428,192	5,395,392	....	....	....	52,896

1913 8/11	Fragillaria capucina	Gomphonema constrictum	Gyrosigma acuminatum	Gyrosigma kützingii	Gyrosigma scalproides	Melosira granulata
7 A.M.	6,400	....	....	52,896	158,688	10,790,784
8 A.M.	....	....	....	52,896	343,824	10,526,304
9 A.M.	....	....	....	....	158,688	8,436,912
10 A.M.	....	....	....	....	343,824	8,198,880
11 A.M.	....	....	....	....	158,688	8,489,808
12 M.	....	52,896	....	....	52,896	9,568,384
1 P.M.	....	....	....	211,584	343,824	12,668,592
2 P.M.	52,896	....	....	105,792	449,616	19,883,104
3 P.M.	6,400	....	52,896	158,688	819,888	20,655,888
4 P.M.	....	....	....	6,400	766,992	24,067,680
5 P.M.	....	52,896	52,896	396,720	925,680	34,990,704
5:48 P.M.	52,896	....	52,896	52,896	1,057,920	31,737,600
6:40 P.M.	....	....	....	105,792	661,200	35,863,488

1913 8/11	Melosira varians	Navicula alpestris	Navicula bacillum	Navicula didyma	Navicula dubia	Navicula gracilis
7 A.M.	....	....	158,688	52,896	....	1,269,504
8 A.M.	....	6,400	105,792	....	....	1,163,712
9 A.M.	....	....	....	....	12,800	766,992
10 A.M.	52,896	105,792	158,688	52,896	....	1,005,024
11 A.M.	52,896	12,800	....	....	52,896	1,163,712
12 M.	....	52,896	....	....	....	819,888
1 P.M.	....	12,800	105,792	....	....	872,784
2 P.M.	....	....	105,792	....	....	1,163,712
3 P.M.	6,400	52,896	....	....	....	872,784
4 P.M.	....	158,688	52,896	....	....	1,269,504
5 P.M.	6,400	105,792	....	....	....	1,586,880
5:48 P.M.	....	158,688	105,792	....	....	1,216,608
6:40 P.M.	....	52,896	52,896	....	....	2,142,288

TABLE 5.—PLANKTON ORGANISMS PER CUBIC METER IN SMITH'S CANAL, HOURLY SERIES IN 1913—(*Continued*)

1913 8/11	Navicula viridis	Nitsschia acicularis	Nitzschia sigma	Nitsschia vermicularis	Pleurostauron parvulum	Stauroneis phoenicenteron
7 A.M.		449,616	52,896			
8 A M.		502,512	52,896	52,896		
9 A.M		343,824	158,688	52,896		
10 A.M.		158,688		6,400	52,896	
11 A M.		396,720	343,824			
12 M.		105,792	158,688			
1 P.M.		264,480				52,896
2 P.M		502,512	158,688	52,896	52,896	
3 P M.		661,200	59,296	105,792	105,792	
4 P M.		343,824	158,688	52,896		
5 P M.		872,784	211,584	52,896	52,896	52,896
5.48 P M.	6,400	1,322,400			52,896	
6.40 P M.	6,400	1,877,808	158,688		52,896	

1913 8/11	Surirella sp	Synedra ulna	Synedra radians	Total Bacillariaceae	Closterium accuminatum	Closterium acerosum
7 A M.	158,688	158,688	343,824	29,525,024	6,400	6,400
8 A M.	343,824	211,584	158,688	17,451,424	6,400	6,400
9 A M	211,584	396,720	264,480	17,289,844		6,400
10 A M.	60,800	608,304	264,480	17,866,704		
11 A M	211,584	396,720	555,408	17,179,664		6,400
12 M	80,000	343,824	105,792	15,688,528		
1 P M	158,688	158,688	502,512	21,719,160		
2 P M	396,720	211,584	714,096	31,129,904		19,200
3 P M.	608,304	211,584	502,512	31,307,184		25,600
4 P M.	502,512	52,896	714,096	34,769,072		6,400
5 P M	449,616	105,792	264,480	47,514,016		52,896
5.48 P M	396,720	396,720	555,408	44,121,664		12,800
6.40 P M	396,720	714,096	1,375,296	51,818,032		

1913 8/11	Closterium rostratum	Mougeotia sp	Staurastrum A	Staurastrum sp	Total Conjugatae	Total Chlorophyll bearing
7 A M.	6,400	264,480	6,400	52,896	342,966	35,677,850
8 P M	6,400	608,304	52,896		680,400	24,947,312
9 A M.		608,304	6,400		621,104	24,220,324
10 A M.	52,896	608,304	52,896		714,096	25,405,888
11 A M.	6,400	211,584	105,792		330,176	23,936,704
12 M		661,200	12,800	52,896	726,896	25,301,712
1 P M	6,400	766,992	52,896		826,288	29,217,400
2 P M	52,896	343,824	264,480		528,960	42,512,800
3 P M	52,896	1,057,920	105,792		1,242,208	46,497,248
4 P M	52,896	872,784	158,688		1,090,758	49,945,672
5 P M	105,792	1,216,608	52,896		1,428,192	65,839,888
5·48 P.M.	52,896	1,110,816	158,688		1,335,200	60,499,184
6:40 P M		2,089,392	105,792	52,896	2,248,080	73,644,688

1913 8/11	Total Algae	Cercomonas crassicauda	Cercomonas sp	Chlamydomonas sp	Chromulina sp	Eudorina elegaus
7 A.M.	31,996,026				2,750,592	211,584
8 A M.	21,060,304				2,539,008	343,824
9 A.M.	19,557,124				2,750,592	396,720
10 A M.	21,066,912			211,584	2,591,904	396,720
11 A.M.	20,339,776		52,896	105,792	1,719,120	105,792
12 M.	19,958,608		52,896		3,147,312	502,512
1 P.M.	26,413,256	52,896			1,719,120	211,584
2 P.M.	39,724,656	52,896			1,877,808	396,720
3 P.M.	42,793,872				2,142,288	555,408
4 P.M.	46,524,776	52,896			1,824,912	264,480
5 P.M.	61,656,448	52,896	52,896	555,408	2,089,392	608,304
5:48P.M.	56,696,516		105,792	105,792	2,248,080	555,408
6:40P.M.	68,856,096	52,896		502,512	2,856,384	343,824

TABLE 5.—PLANKTON ORGANISMS PER CUBIC METER IN SMITH'S CANAL, HOURLY SERIES IN 1913—(*Continued*)

1913 8/11	Euglena viridis	Gonium pectorale	Hemidinium nasutum	Mallomonas sp	Pandorina morum	Peridinium cinctum
7 A.M.		6,400	264,480		52,896	
8 A.M.	6,400		105,792		105,792	
9 A.M.			502,512		158,688	
10 A.M.	158,688		608,304		52,896	
11 A.M.			396,720	52,896	396,720	
12 M.	52,896	6,400	396,720		264,480	
1 P.M.	52,896	12,800	158,688		158,688	
2 P.M.			158,688		6,400	
3 P.M.		52,896	105,792		52,896	52,896
4 P.M.			449,616		6,400	
5 P.M.			158,688	105,792	52,896	52,896
5:48 P.M.	105,792		52,896		19,200	
6:40 P.M.			449,616			52,896

1913 8/11	Platydorina caudata	Pleodorina californica	Pleodorina illinoisensis	Trachelomonas euchlora	Trachelomonas volvocina	Total Mastigophora
7 A.M.	105,792	25,600		52,896	211,584	3,681,824
8 A.M.	12,800	52,896	6,400		714,096	3,887,008
9 A.M.	6,400	32,000	6,400	105,792	555,408	4,663,200
10 A.M.	54,400	52,896		211,584	608,304	4,338,976
11 A.M.	105,792	158,688			449,616	3,596,928
12 M.	105,792	60,800			502,512	5,343,104
1 P.M.	105,792	67,200		52,896	211,584	2,804,144
2 P.M.	19,200	158,688			396,720	2,788,144
3 P.M.	48,000	32,000		105,792	555,408	3,703,376
4 P.M.	32,000	25,600		52,896	714,096	3,473,792
5 P.M.	19,200	112,000	6,400	158,688	264,480	4,236,336
5:48 P.M.		54,400			555,408	3,802,768
6:40 P.M.	12,800	48,000			925,680	4,794,992

1913 8/11	Amoeba proteus	Amoeba radiosa	Cyphoderia ampulla	Difflugia pyriformis	Hyalodiscus sp	Microgromia socialis
7 A.M.				105,792		
8 A.M.						105,792
9 A.M.		52,896				
10 A.M.			52,896	52,896		
11 A.M.			52,896	105,792		105,792
12 M.						105,792
1 P.M.				52,896	105,792	
2 P.M.					52,896	158,688
3 P.M.						
4 P.M.		105,792		52,896		158,688
5 P.M.					396,720	
5:48 P.M.	396,720				396,720	105,792
6:40 P.M.	396,720				925,680	52,896

1913 8/11	Nebela sp	Nuclearia simplex	Total Rhizopoda	Actinophrys sol	Heterophrys fockei	Heterophrys sp
7 A.M.			158,688		211,584	
8 A.M.			211,584		211,584	
9 A.M.	105,792		158,688	52,896	52,896	
10 A.M.			105,792			
11 A.M.			264,480	52,896	105,792	
12 M.		158,688	264,480		52,896	
1 P.M.		52,896	214,584		52,896	
2 P.M.			211,584		396,720	
3 P.M.		105,792	211,584	158,688	343,824	502,512
4 P.M.		52,896	370,272		502,512	502,512
5 P.M.			396,720	105,792	449,616	766,992
5:48 P.M.		211,584	1,110,816		158,688	343,824
6:40 P.M.	105,792		1,481,088		158,688	396,720

TABLE 5.—PLANKTON ORGANISMS PER CUBIC METER IN SMITH'S CANAL, HOURLY SERIES IN 1913—(*Continued*)

1913 8/11	Raphidiophrys elegans	Total Heliosoa	Cyclidium sp	Halteria grandinella	Holophrya sp	Tintinnidium fluviatile
7 A.M.		211,584			264,480	105,792
8 A.M.	105,792	211,584			661,200	502,512
9 A.M.		105,792			1,005,024	211,584
10 A.M.			105,792		1,824,912	502,512
11 A M.		158,688			1,428,192	661,200
12 M.	52,896	105,792			2,195,184	872,784
1 P.M.	105,792	158,688	52,896		925,680	264,480
2 P.M.		396,720			555,408	343,824
3 P M.		1,005,024	52,896		661,200	105,792
4 P.M.		1,005,024			264,480	52,896
5 P.M.		1,322,400		52,896	449,616	52,896
5:48 P M.		502,512		105,792	52,896	264,480
6:40 P.M.		555,408	105,792		1,428,192	264,480

1913 8/11	Vorticella B	Vorticella sp	Total Ciliata	Acineta sp	Total Suctoria	Total Protozoa without Mastigophora
7 A M.		1,322,400	1,692,672			2,062,944
8 A.M.		3,411,792	4,575,514	6,400	6,400	5,005,082
9 A.M	819,888	1,533,984	2,750,592			3,015,072
10 A.M	555,408	2,591,904	5,031,520			5,137,312
11 A M.	661,200	2,089,392	4,178,784			4,601,952
12 M.	1,586,880	2,433,216	5,501,184			5,871,456
1 P.M.	819,888	1,930,704	3,180,160	6,400	6,400	3,559,832
2 P M	396,720	2,036,496	2,935,728			3,544,032
3 P M.	158,688	1,772,016	2,829,936			4,046,544
4 P M	158,688	1,428,192	1,745,568			3,120,864
5 P M	211,584	925,680	1,487,488	12,800	12,800	3,219,408
5:48 P M.	396,720	1,216,608	1,639,776			3,253,104
6.40 P M	343,824	1,375,296	3,226,656			4,263,144

1913 8/11	Total Protozoa with Mastigophora	Collotheca pelagica	Collotheca sp	Ptygura sp	Total Rhizota	Rotaria rotatoria
7 A M	5,744,768					6,400
8 A M.	8,892,090					
9 A M.	7,678,272		6,400		6,400	
10 A M.	9,476,288				52,896	
11 A M	8,198,880					6,400
12 M	11,214,560					
1 P.M	6,363,976					6,400
2 P.M.	6,332,176					19,200
3 P M	7,749,920		6,400	6,400	12,800	52,896
4 P M.	6,594,656	12,800		105,792	118,592	
5 P M.	7,455,744		6,400		6,400	6,400
5:48 P.M.	7,055,872	6,400	6,400		12,800	12,800
6:40 P.M	9,058,136					

1913 8/11	Rotifer unidentified	Total Bdelloida	Anureaopsis fissa	Anureaopsis sp	Asplanchna brightwellii	Asplanchnopus sp
7 A.M.	158,688	165,088			6,400	
8 A.M.	158,688	158,688	52,896			
9 A.M.	343,824	343,824	105,792			
10 A.M.	158,688	158,688	105,792			105,792
11 A.M.	502,512	508,912				
12 M.	343,824	343,824	105,792			
1 P.M.	158,688	165,088	52,896	52,896	6,400	105,792
2 P.M.	343,824	363,024	52,896		6,400	
3 P.M.	52,896	122,192	6,400	52,896	6,400	19,200
4 P.M.	105,792	105,792		105,792	6,400	6,400
5 P.M.	105,792	112,192	19,200	52,896		
5:48 P.M.	211,584	224,384		32,000		19,200
6:40 P.M.	158,688	158,688	19,200	52,896	6,400	52,896

TABLE 5.—PLANKTON ORGANISMS PER CUBIC METER IN SMITH'S CANAL, HOURLY SERIES IN 1913—(*Continued*)

1913 8/11	Brachionus angularis	Brachionus angularis caudatus	Brachionus budapestinensis	Brachionus calyciflorus	Brachionus capsuliflorus	Brachionus egg; attached, female
7 A.M.	...	1,216,608	...	158,688	25,600	...
8 A.M.	6,400	2,380,320	...	396,720	12,800	52,896
9 A.M.	...	2,380,320	6,400	264,480	41,600	...
10 A.M.	...	1,930,704	...	264,480	105,792	264,480
11 A.M.	52,896	1,163,712	6,400	158,688	67,200	52,896
12 M.	...	3,253,104	...	211,584	105,792	52,896
1 P.M.	...	1,666,224	52,896	80,000	12,800	52,896
2 P.M.	52,896	925,680	...	140,800	19,200	158,688
3 P.M.	...	555,408	...	158,688	6,400	...
4 P.M.	...	714,096	...	105,792	52,896	211,584
5 P.M.	...	766,992	...	80,000	25,600	211,584
5:48 P.M.	...	1,163,712	6,400	105,792	25,600	264,480
6:40 P.M.	...	1,586,880	52,896	158,688	25,600	396,720

1913 8/11	Brachionus egg; attached, male	Brachionus egg; free, female	Brachionus egg, winter	Brachionus male	Brachionus patulus	Brachionus plicatilis
7 A.M.	...	608,304	...	...	6,400	...
8 A.M.	105,792	1,057,920	...	...	...	...
9 A.M.	52,896	343,824	264,480	...	6,400	...
10 A.M.	...	661,200	105,792	...	12,800	52,896
11 A.M.	...	343,824	...	52,896	...	...
12 M.	...	766,992	...	...	12,800	52,896
1 P.M.	...	158,688	...	...	...	...
2 P.M.	...	105,792	...	...	52,896	...
3 P.M.	...	52,896	...	...	6,400	...
4 P.M.	...	...	...	...	25,600	...
5 P.M.	32,000	105,792	...	...	6,400	...
5:48 P.M.	52,896	608,304	...	...	...	...
6:40 P.M.	52,896	343,824	...	6,400	6,400	...

1913 8/11	Brachionus urceus	Brachionus with parasites	Diurella egg	Filinia egg, free	Filinia longiseta	Keratella cochlearis
7 A.M.	...	6,400	158,688	661,200	...	52,896
8 A.M.	25,600	...	...	714,096	...	...
9 A.M.	6,400	105,792	211,584	555,408	52,896	...
10 A.M.	...	...	...	555,408	6,400	12,800
11 A.M.	...	...	52,896	396,720	...	...
12 M.	...	...	158,688	766,992	...	6,400
1 P.M.	6,400	...	158,688	502,512	...	...
2 P.M.	158,688	...	105,792	449,616	...	6,400
3 P.M.	52,896	...	52,896	105,792	...	...
4 P.M.	6,400	...	52,896	158,688	...	...
5 P.M.	48,000	...	158,688	396,720	...	...
5:48 P.M.	12,800	...	264,480	449,616	...	6,400
6:40 P.M.	158,688	...	211,584	608,304	...	...

1913 8/11	Keratella egg, attached	Keratella egg, free	Keratella quadrata	Polyarthra trigla	Polyarthra trigla egg; attached, female	Rotifer egg, winter
7 A.M.	52,896	396,720	211,584	766,992	...	52,896
8 A.M.	...	396,720	396,720	1,586,880	...	6,400
9 A.M.	52,896	502,512	343,824	2,248,080	...	105,792
10 A.M.	...	766,992	502,512	1,322,400	...	105,792
11 A.M.	...	449,616	264,480	1,877,808	...	52,896
12 M.	...	819,888	264,480	1,824,912	52,896	264,480
1 P.M.	...	502,512	60,800	1,005,024	...	105,792
2 P.M.	...	819,888	211,584	1,269,504	...	52,896
3 P.M.	...	661,200	67,200	1,269,504	105,792	158,688
4 P.M.	...	264,480	52,896	608,304	158,688	52,896
5 P.M.	6,400	608,304	52,896	766,992	52,896	52,896
5:48 P.M.	...	714,096	158,688	1,057,920	105,792	52,896
6:40 P.M.	52,896	925,680	264,480	872,784	52,896	25,600

TABLE 5.—PLANKTON ORGANISMS PER CUBIC METER IN SMITH'S CANAL, HOURLY SERIES IN 1913—(*Concluded*)

1913 8/11	Synchaeta sp.	Trichocerca capucina	Trichocerca iernis	Total Ploima	Total Rotifera	Bosmina longirostris
7 A.M.	......	......	158,688	4,564,560	4,729,648	52,896
8 A.M.	52,896	......	158,688	7,466,640	7,615,328	......
9 A.M.	52,896	......	343,824	4,846,384	5,196,608	52,896
10 A.M.	......	52,896	264,480	7,199,408	7,410,992	......
11 A.M.	52,896	......	714,096	5,759,920	6,268,832	......
12 M.	6,400	12,800	766,992	9,612,576	9,956,400	......
1 P.M.	......	......	343,824	4,979,936	5,145,024	52,896
2 P.M.	6,400	......	211,584	4,817,607	5,180,631	......
3 P.M.	6,400	......	211,584	3,575,840	3,704,432	......
4 P.M.	......	......	32,000	2,721,600	2,852,992	6,400
5 P.M.	......	52,896	25,600	3,512,752	3,631,344	6,400
5:48 P.M.	158,688	......	211,584	5,471,152	5,708,336	......
6:40 P.M.	......	......	264,480	6,199,188	7,357,876	6,400

1913 8/11	Sida	Total Cladocera	Cyclops	Nauplius	Total Copepoda	Total Entomostraca	Total Organisms
7 A.M.	52,896	105,792	158,688	158,688	317,376	423,168	42,893,610
8 A.M.	12,800	12,800	86,400	158,688	245,088	257,888	37,825,610
9 A.M.	12,800	65,696	86,400	105,792	192,192	257,888	32,689,892
10 A.M.	25,600	25,600	54,400	158,688	213,088	238,688	38,192,880
11 A.M.	6,400	6,400	73,600	80,000	153,600	160,000	34,967,488
12 M.	19,200	19,200	54,400	211,584	265,984	285,184	41,414,752
1 P.M.	......	52,896	25,600	86,400	112,000	164,896	38,087,152
2 P.M.	19,200	19,200	80,000	92,800	172,800	192,000	51,429,463
3 P.M.	52,896	52,896	60,800	12,800	73,600	126,496	54,374,720
4 P.M.	52,896	52,896	60,800	52,896	113,696	172,992	56,092,520
5 P.M.	......	6,400	99,200	105,792	204,992	211,584	72,902,032
5:48 P.M.	6,400	6,400	99,200	52,896	152,096	158,496	69,619,120
6:40 P.M.	12,800	19,200	140,800	105,792	246,592	265,792	85,531,500

TABLE 6.—VOLUMES OF CATCHES, 1913

Date 1913	Volume in cubic centimeter per ¼ cubic meter			Estimated percentage of plankton			Number of hauls			Number of forms recorded		
	I	II	III	I	II	III	I	II	III	I	II	III
1/ 5	0.5	0.4		50%	40%		13	7		30	31	
1/ 8	0.55			50%			13			28		
1/11			0.55			40%			25			24
1/12	0.35	0.25		30%	50%		13	7		30	37	
1/15	0.8			60%			13			42		
1/19	0.55	0.35	0.55	60%	60%	40%	8	7	13	43	45	41
1/22	0.6			60%			9			56		
1/25		0.65	0.45		70%	50%		6	25		60	46
1/26	1.0						9			39		
1/29	0.8			90%			8			46		
2/ 2	0.85	0.65	0.6	85%	75%	80%	9	7	13	45	50	51
2/ 5	0.95			85%			9			48		
2/ 8	1.0	0.85	0.6	80%	70%	80%	9	7	13	46	49	45
2/12	1.7			85%			10			50		
2/15	1.0	0.75	0.65	80%	60%	80%	9	7	13	54	50	59
2/19	0.85			60%			9			61		
2/23	1.55	0.65	0.6	70%	60%	70%	9	7	13	60	62	64
2/26	1.65			60%			13			59		
3/ 1	1.4	0.65	0.75	85%	40%	50%	9	7	13	55	52	57
3/ 5	3.95			85%			13			46		
3/ 8	5.2	1.4	0.65	85%	10%	50%	9	7	13	48	52	60
3/12	6.8			80%			16			43		
3/15	1.8	1.95	0.8	90%	15%	50%	10	7	13	55	58	70
3/19	2.1			80%			13			56		
3/23	1.9	0.8	0.8	85%	10%	60%	9	7	13	63	74	70
3/26	1.8			85%			13			51		
3/29	1.85	0.7	1.0	80%	15%	40%	9	7	13	54	78	72
4/ 2	2.5			90%			9			57		
4/ 5	2.7	1.7	0.55	90%	15%	40%	9	5	13	58	75	71
4/ 9	2.4			95%			9			54		
4/13	1.85	0.5	0.75	95%	15%	20%	9	5	12	62	70	67
4/16	2.2			80%			10			56		
4/19	2.65	1.85	0.7	90%	10%	75%	13	5	13	47	58	61
4/23	2.2			85%			9			65		
4/26	3.1	0.8	0.55	90%	20%	25%	13	5	13	70	68	71
4/30	2.3			80%			9			51		
5/ 3	2.1	3.05	0.65	65%	4%	50%	9	5	13	53	58	63
5/ 7	2.6			90%			9			55		
5/10	3.0	6.6	0.55	95%	4%	80%	9	6	12	64	47	56
5/14	2.8			90%			9			51		
5/17	3.4	5.6	0.65	10%	4%	55%	9	6	13	65	64	70
5/21	2.25			85%			9			49		
5/24	2.75	6.0	0.6	50%	5%	50%	8	5	9	59	59	58
5/27	2.95			80%			9			58		
5/31	3.6	6.7	0.7	80%	2%	90%	9	3	13	53	52	46
6/ 3	2.9			95%			9			58		
6/ 7	2.4	3.15	0.5	95%	5%	45%	9	3	9	54	60	66
6/11	2.8			55%			9			50		
6/16	1.85	1.9	0.6	65%	4%	50%	9	6	13	65	63	61
6/18	2.65			85%			9			56		
6/21	2.8	1.2	0.6	90%	10%	60%	9	7	13	57	68	78
6/25	3.45			92%			13			72		
6/28	3.1	1.95	0.75	92%	15%	65%	13	9	13	61	77	72
7/ 3	2.7			80%			9			56		
7/ 5	3.05	0.95	0.7	93%	30%	65%	9	9	13	63	66	72
7/ 9	2.7			85%			9			59		
7/12	3.85	2.1	1.7	90%	40%	85%	9	9	13	55	82	94
7/16	3.9			92%			9			57		

TABLE 6.—VOLUMES OF CATCHES, 1913—(*Concluded*)

Date 1913	Volume in cubic centimeter per ¼ cubic meter			Estimated percentage of plankton			Number of hauls			Number of forms recorded		
	I	II	III	I	II	III	I	II	III	I	II	III
7/19	4.1	1.7	0.95	85%	60%	80%	9	9	13	50	66	60
7/23	3.9			85%			9			52		
7/26	4.3	1.4	1.65	90%	90%	50%	9	10	13	63	70	83
7/30	4.5			92%			9			61		
8/ 2	4.2	2.3	1.35	90%	80%	90%	9	9	13	66	88	76
8/ 6	4.5			93%			9			52		
8/ 9	4.7	2.4	2.85	95%	75%	50%	9	9	13	63	83	98
8/13	4.75			75%			9			75		
8/15	5.1	2.3	1.4	80%	80%	70%	9	9	13	72	98	44
8/20	6.1			60%			9			68		
8/23	4.1	2.0	4.6	80%	85%	80%	9	8	13	71	86	92
8/27	4.6			95%			9			65		
8/31	5.2	2.9	1.7	85%	90%	80%	9	8	13	58	84	78
9/ 2	4.4			85%			9			71		
9/ 6	3.8	2.0	2.8	55%	90%	80%	9	8	13	67	66	85
9/ 9	3.9			85%			9			68		
9/13	3.9	2.5	1.75	75%	55%	85%	9	9	13	63	81	79
9/17	3.2			80%			9			63		
9/20	2.0	1.9	1.9	95%	85%	95%	9	9	13	58	78	67
9/24	1.8			95%			9			73		
9/27	3.15	2.5	1.55	95%	30%	90%	9	9	13	63	70	76
10/ 1	2.4			80%			9			69		
10/ 4	2.05	1.65	1.8	85%	30%	55%	9	7	13	67	74	72
10/ 8	2.7			75%			9			79		
10/11	2.45	2.1	1.55	85%	30%	40%	9	8	13	70	74	73
10/15	4.6			20%			9			78		
10/18	1.7	1.25	1.45	50%	30%	40%	9	8	13	57	68	53
10/22	2.3			50%			9			69		
10/26	1.65	1.2	1.35	60%	25%	40%	9	9	13	57	62	75
10/29	1.6			60%			9			78		
11/ 2	1.15	1.2	1.2	60%	30%	50%	9	9	13	64	76	71
11/ 5	0.9			25%			9			54		
11/ 8	0.5	1.3	1.5	40%	20%	15%	9	9	19	44	57	66
11/12	1.25			30%			9			69		
11/15	0.6	0.8	0.6	30%	25%	45%	9	9	13	56	64	65
11/19	1.35			15%			13			83		
11/22	1.3	0.7	0.95	15%	15%	20%	9	9	13	77	67	81
11/26	1.15			40%			9			64		
11/30	1.35	1.1	0.6	15%	45%	25%	12	9	13	73	57	62
12/ 3	1.3			40%			13			72		
12/ 6	0.9	0.8	1.1	50%	50%	35%	9	8	13	64	46	61
12/10	0.9			15%			7			66		
12/14	0.7	0.8	0.85	15%	25%	25%	12	7	17	71	49	52
12/17	0.8			20%			7			63		
12/20	1.9	0.5	0.65	15%	25%	20%	9	7	17	67	56	40
12/24	0.55			25%			7			78		
12/27	1.0	1.30	0.7	15%	15%	10%	9	7	13	71	54	51
12/31	0.95			20%			9			59		

DAILY, STATION I.					HOURLY, STATION IIIa.				
Date 1913	Volume in cubic centimeter per ¼ cubic meter	Estimated percentage of plankton	Number of hauls	Number of forms	Date 1913 8/11	Volume in cubic centimeter per ¼ cubic meter	Estimated percentage of plankton	Number of hauls	Number of forms
7/ 5	3.05	93%	9	63					
7/ 6	2.5	70%	9	57					
7/ 7	3.2	75%	9	54					
7/ 8	3.6	80%	9	55					
7/ 9	2.7	85%	9	59					
7/10	3.4	90%	9	54					
7/11	4.1	85%	9	45	7 A.M.	2.4	50%	6	76
7/12	3.85	90%	9	55	8 A.M.	2.3	60%	6	74
7/13	5.05	92%	12	56	9 A.M.	2.3	70%	6	75
7/14	4.35	80%	9	64	10 A.M.	2.5	50%	6	73
7/15	4.40	90%	10	55	11 A.M.	2.4	50%	6	79
7/16	3.9	92%	9	57	12 M.	2.4	75%	6	78
7/17	4.65	50%	10	50	1 P.M.	2.07	80%	6	81
7/18	6.4	90%	13	50	2 P.M.	2.07	75%	6	80
7/19	4.1	85%	9	50	3 P.M.	2.07	85%	6	91
7/20	4.9	92%	9	52	4 P.M.	2.07	85%	6	86
7/21	4.3	92%	9	54	5 P.M.	2.3	80%	6	94
7/22	4.2	92%	13	56	5:48 P.M.	2.3	85%	6	86
7/23	3.9	85%	9	52	6:40 P.M.	2.5	80%	6	93
7/24	3.35	95%	9	64					
7/25	3.85	92%	9	57					
7/26	4.3	90%	9	63					
7/27	5.8	95%	13	67					
7/28	4.45	95%	9	62					
7/29	4.3	95%	9	64					
7/30	4.5	92%	9	61					
7/31	4.2	90%	9	59					
8/ 1	3.8	92%	9	53					
8/ 2	4.2	90%	9	66					
8/ 3	3.7	95%	9	64					
8/ 4	3.6	95%	9	65					

TABLE 7.

Date 1913	Time of first collection	Temperature centigrade				Air conditions	Water conditions	Anchor or drift	Number of hauls		
			I	II	III				I	II	III
1/ 1	3:30 P.M.	Air				Clear		a	13		
		Water									
1/ 5	4:00 P.M.	Air		4.5		High wind; clear	Rough	a		7	
		Water		4							
1/ 8	5:00 P.M.	Air	2.5			Wind; sleet	Choppy	a	13		
		Water	5.5								
1/11	3:00 P.M.	Air			6.5	Wind; cloudy	Choppy	a			25
		Water			4						
1/12	2:00 P.M.	Air	13	15		Wind; clear	Choppy	a	13	7	
		Water	6.5	13							
1/15	4:00 P.M.	Air	9			Cloudy		a	13		
		Water	7								
1/19	11:00 A.M.	Air	8	11	9.5	Wind; clear	Choppy	d	8	7	13
		Water	8.5	8	8						
1/22	4:00 P.M.	Air	9.5			No wind; rain	Smooth	d	9		
		Water	10								
1/25	2:00 P.M.	Air		17	19	No wind; clear	Smooth	d		6	25
		Water		8	10						
1/26	10:00 A.M.	Air	14			No wind; clear	Smooth	d	9		
		Water	10								
1/29	4:00 P.M.	Air	17.5			Light wind; clear	Wavy	d	8		
		Water	11.5								
2/ 2	11:30 A.M.	Air	14	17.5	17	Breeze; clear	Ripply	d	9	7	13
		Water	11	10	10						
2/ 5	4:00 P.M.	Air	16.5			No wind; cloudy	Smooth	d	9		
		Water	12.5								
2/ 8	10:30 A.M.	Air	15	15	16	Light wind; rain	Wavy	d	9	7	13
		Water	14.5	10.5	11.5						
2/12	4:00 P.M.	Air	19			Breeze; clear	Ripply	d	10		
		Water	15.5								
2/15	10:00 A.M.	Air	18	19	15.5	No wind; clear	Smooth	d	9	7	13
		Water	15	13.5	13						
2/19	4:00 P.M.	Air	14.5			High wind; clear	Rough	a	9		
		Water	12.5								
2/23	9:00 A.M.	Air	10	12	13	High wind; part cloudy	Rough	a	9	7	13
		Water	11.5	9	9						
2/26	4:00 P.M.	Air	13			High wind; cloudy	Rough	a	13		
		Water	12								
3/ 1	1:00 P.M.	Air	13.5	15	15	Light wind; cloudy	Wavy	a	9	7	13
		Water	13	10	10						
3/ 5	4:00 P.M.	Air	23.5			Light wind; clear	Wavy	a	13		
		Water	15								
3/ 8	9:30 A.M.	Air	23	21.5	22.5	Light wind; clear	Wavy	a	9	7	13
		Water	18	15	15						
3/12	4:00 P.M.	Air	17.5			Light wind; clear	Wavy	a	16		
		Water	16.5								
3/15	9:00 A.M.	Air	14.5	12	11.5	Breeze; clear	Ripply	a	10	7	13
		Water	14.5	12	12						
3/19	4:00 P.M.	Air	14.5			High wind; part cloudy	Rough	a	13		
		Water	14.5								
3/23	9:00 A.M.	Air	12	9.5	13	Wind; cloudy	Choppy	a	9	7	13
		Water	14	12	12.5						
3/26	4:30 P.M.	Air	18			Breeze; clear	Ripply	a	13		
		Water	14.5								
3/29	9:00 A.M.	Air	20	17	18.5	Wind; clear	Choppy	a	9	7	13
		Water	12	13	14.5						
4/ 2	4:30 P.M.	Air	18			Light wind; clear	Wavy	a	9		
		Water	17								

TABLE 7.—(*Continued*)

Date 1913	Time of first collection	Temperature centigrade				Air conditions	Water conditions	Anchor or drift	Number of hauls		
			I	II	III				I	II	III
4/ 5	9:00 A.M.	Air	15.5	13.5	15	Wind; cloudy	Choppy	a	9	5	13
		Water	18	14.5	15						
4/ 9	12:00 M.	Air	24			Breeze; clear	Ripply	a	9		
		Water	18								
4/13	9:00 A.M.	Air	18.5	16.5	17	Breeze; part cloudy	Ripply	a	9	5	12
		Water	18.5	17.5	17.5						
4/16	4:00 P.M.	Air	24			Breeze; clear	Ripply	a	10		
		Water	20								
4/19	9:00 A.M.	Air	21	18	19	Breeze; clear	Ripply	a	13	5	13
		Water	19	15	16.5						
4/23	4:00 P.M.	Air	25			Breeze; clear	Ripply	a	9		
		Water	20								
4/26	9:00 A.M.	Air	26.5	23.5	24.5	Breeze; clear	Ripply	a	13	5	13
		Water	20	18.5	19						
4/30	4:00 P.M.	Air	20			Wind; clear	Choppy	a	9		
		Water	19								
5/ 3	8:45 A.M.	Air	23	21	22	Light wind; clear	Wavy	a	9	5	13
		Water	18	14	16						
5/ 7	11:00 A.M.	Air	22			Light wind; clear	Wavy	a	9		
		Water	20								
5/10	9:00 A.M.	Air	22	21.5	21.5	Wind; part cloudy	Choppy	a	9	6	12
		Water	21	17	20.5						
5/14	4:00 P.M.	Air	26			Wind; clear	Choppy	a	9		
		Water	21								
5/17	12:00 M.	Air	26	25	26	Wind; cloudy	Choppy	a	9	6	13
		Water	21	19	19						
5/21	4:00 P.M.	Air	27.5			Light wind; part cloudy	Wavy	a	9		
		Water	23								
5/24	9:00 A.M.	Air	26.5	27	25.5	Light wind; clear	Wavy	a	8	5	9
		Water	23	19.5	21						
5/27	4:00 P.M.	Air	18			Light wind; rain	Wavy	a	9		
		Water	23								
5/31	12:00 M.	Air	31	30.5	32	Breeze; clear	Ripply	a	9	3	13
		Water	27	19.5	27						
6/ 3	5:30 P.M.	Air	22.5			Breeze; cloudy	Ripply	a	9		
		Water	25								
6/ 7	9:00 A.M.	Air	23	23.5	22.5	Wind; part cloudy	Choppy	a	9	3	9
		Water	25	20.5	22.5						
6/11	4:00 P.M.	Air	29			Wind; clear	Choppy	a	9		
		Water	23								
6/16	6:45 A.M.	Air	21			No wind; clear	Smooth	d	9		
		Water	20								
6/16	4:00 P.M.	Air		27	24	Wind; clear	Choppy	d		6	13
		Water		21	21						
6/18	1:00 P.M.	Air	25			Breeze; cloudy	Ripply	d	9		
		Water	22								
6/21	9:00 A.M.	Air	30	28.5	28	Wind; clear	Choppy	d	9	7	13
		Water	23.5	26.5	29						
6/25	1:30 P.M.	Air	22			High wind; part cloudy	Rough	d	13		
		Water	22.5								
6/28	9:00 A.M.	Air	23.5	21	22.5	Wind; clear	Choppy	d	13	9	13
		Water	23	20	20.5						
7/ 3	9:00 A.M.	Air	24			Wind; clear	Choppy	d	9		
		Water	23.5								
7/ 5	9:00 A.M.	Air	32	28.5	30.5	No wind; hazy	Smooth	d	9	9	13
		Water	26	23.5	25						
7/ 9	10:30 A.M.	Air	31			Light wind; clear	Ripply	d	9		
		Water	26								

TABLE 7.—(*Continued*)

Date 1913	Time of first collection	Temperature centigrade				Air conditions	Water conditions	Anchor or drift	Number of hauls		
			I	II	III				I	II	III
7/12	8:40 A.M.	Air	32	32		No wind; clear	Smooth	d	9	9	13
		Water	27	25							
7/16	10:45 A.M.	Air	28			Breeze; clear	Ripply	a	9		
		Water	26								
7/19	10:00 A.M.	Air	29	26	27.5	Breeze; hazy	Ripply	a	9	9	13
		Water	27	24	25						
7/23	10:30 A.M.	Air	27			Breeze; light rain	Ripply	a	9		
		Water	25								
7/26	9:00 A.M.	Air	26.5	22.5	24.5	Breeze; part cloudy	Ripply	d	9	10	13
		Water	26	23	24.5						
7/30	10:40 A.M.	Air	27.5			Breeze; hazy	Ripply	a	9		
		Water	25.5								
8/ 2	8:45 A.M.	Air	27.5	25.5	26.5	No wind; clear	Smooth	a	9	9	13
		Water	26	24	25						
8/ 6	10:30 A.M.	Air	33			Breeze; clear	Ripply	a	9		
		Water	27								
8/ 9	8:45 A.M.	Air	29	24.5	25	Breeze; part cloudy	Ripply	a	9	9	13
		Water	27	25	25.5						
8/13	11:00 A.M.	Air	24			Light wind; clear	Wavy	a	9		
		Water	26.5								
8/15	9:00 A.M.	Air	22.5	23.5	24	Breeze; hazy	Ripply	a	9	9	13
		Water	23.5	23	24						
8/20	11:30 A.M.	Air	32.5			Breeze; hazy	Ripply	a	9		
		Water	26								
8/23	8:40 A.M.	Air	33	29	32.5	Breeze; hazy	Ripply	a	9	8	13
		Water	28	24.5	25						
8/27	11:00 A.M.	Air	32.5			No wind; cloudy	Smooth	a	9		
		Water	27								
8/30	8:45 A.M.	Air	33	30.5	31.5	Breeze; hazy	Ripply	a	9	8	13
		Water	28	26	27						
9/ 2	12:00 M.	Air	24			Breeze; part cloudy	Ripply	a	9		
		Water	26.5								
9/ 6	9:15 A.M.	Air	30	26.5	27.5	Breeze; hazy	Ripply	a	9	8	13
		Water	26	24	24						
9/ 9	12:40 P.M.	Air	28			Breeze; hazy	Ripply	a	9		
		Water	26								
9/13	9:00 A.M.	Air	24.5	21	23	Breeze; clear	Ripply	a	9	9	13
		Water	25	23.5	23.5						
9/17	5:00 P.M.	Air	33.5			No wind; clear	Smooth	a	9		
		Water	27								
9/20	9:00 A.M.	Air	23.5	22.5	23	Breeze; cloudy	Ripply	a	9	9	13
		Water	26	23.5	23.5						
9/24	5:00 P.M.	Air	24.5			Breeze; clear	Ripply	a	9		
		Water	22.5								
9/27	7:30 A.M.	Air	23.5	21.5	20.5	Breeze; clear	Ripply	a	9	9	13
		Water	22	20.5	20.5						
10/ 1	4:15 P.M.	Air	29			Breeze; clear	Ripply	a	9		
		Water	22								
10/ 4	8:00 A.M.	Air	20	19	17	Breeze; clear	Ripply	a	9	7	13
		Water	21	20	20						
10/ 8	5:00 P.M.	Air	18.5			Wind; clear	Choppy	a	9		
		Water	19.5								
10/11	7:00 A.M	Air	22	21.5	14	No wind; clear	Smooth	a	9	8	13
		Water	19.5	17	17						
10/15	5:00 P.M.	Air	21			No wind; clear	Smooth	a	9		
		Water	18.5								
10/18	8:00 A.M.	Air	23.5	19.5	19	No wind; clear	Smooth	a	9	8	13
		Water	19	17.5	17						

TABLE 7.—(*Concluded*)

Date 1913	Time of first collection	Temperature centigrade				Air conditions	Water conditions	Anchor or drift	Number of hauls		
			I	II	III				I	II	III
10/22	5:00 P.M.	Air	25			No wind; clear	Smooth	a	9		
		Water	20								
10/26	2:00 P.M.	Air	22.5	27	24	Breeze; clear	Ripply	d	9	9	13
		Water	19	18	18						
10/29	4:30 P.M.	Air	16			Breeze; cloudy	Ripply	a	9		
		Water	19								
11/ 2	10:00 A.M.	Air	19	19.5	17.5	No wind; cloudy	Smooth	a	9	9	13
		Water	19.5	17	17						
11/ 5	4:30 P.M.	Air	17			No wind; cloudy	Smooth	a	9		
		Water	18.5								
11/ 8	10:00 A.M.	Air	20	17	18	No wind; cloudy	Smooth	a	9	9	19
		Water	19.5	16.5	17						
11/12	4:45 P.M.	Air	13			Wind; cloudy	Choppy	a	9		
		Water	17.5								
11/15	8:45 A.M.	Air	16	12	13	No wind; fog	Smooth	a	9	9	13
		Water	17.5	15.5	15						
11/19	5:45 P.M.	Air	14.5			Wind; cloudy	Choppy	a	13		
		Water	16								
11/22	11:00 A.M.	Air	15	13	12.5	Breeze; clear	Ripply	a	9	9	13
		Water	15	12	13						
11/26	7:30 A.M.	Air	9			No wind; cloudy	Smooth	a	9		
		Water	13								
11/30	1:00 P.M.	Air	13	14	13	Wind; clear	Choppy	a	12	9	13
		Water	13	10	11						
12/ 3	4:45 P.M.	Air	14			No wind; clear	Smooth	a	13		
		Water	10								
12/ 6	11:00 A.M.	Air	6.5	4 5	6	No wind; fog	Smooth	a	9	8	13
		water	11	7.5	8						
12/10	4:30 P.M.	Air	8			No wind; fog	Smooth	a	7		
		Water	9								
12/14	11:00 A.M.	Air	13.5	14	14	Wind; clear	Choppy	a	12	7	17
		Water	12	9	9.5						
12/17	4:30 P.M.	Air	10			No wind; cloudy	Smooth	a	7		
		Water	12								
12/20	2:00 P.M.	Air	9	9.5	9.5	No wind; cloudy	Smooth	a	9	7	17
		Water	11.5	8.5	9						
12/24	2:00 P.M.	Air	12			Light wind; cloudy	Wavy	a	7		
		Water	13								
12/27	10:00 A.M.	Air	9	9.5	9	Light wind; cloudy	Wavy	a	9	7	13
		Water	11.5	9	9						
12/31	11:00 A.M.	Air	16			High wind; cloudy	Rough	a	9		
		Water	11.5								
Average for the year		Air	20.6	19.5	19.6						
		Water	19	16.7	17.3						

TABLE 8.—DAILY COLLECTIONS STATION I

Date 1913	Time of first collection	Temperature centigrade		Air conditions	Water conditions	Anchor or drift	Number of hauls
7/ 5	11:20 A.M.	Air	32	No wind; hazy	Smooth	d	9
		Water	26				
7/ 6	9:30 A.M.	Air	32.5	No wind; clear	Smooth	d	9
		Water	26				
7/ 7	8:30 A.M.	Air	29.5	Breeze; clear	Ripply	d	9
		Water	26				
7/ 8	1:30 P.M.	Air	34.5	Wind; hazy	Choppy	d	9
		Water	27				
7/ 9	10:30 A.M.	Air	31	Light wind; clear	Wavy	d	9
		Water	26				
7/10	10:45 A.M.	Air	32	Wind; hazy	Choppy	d	9
		Water	26				
7/11	10:45 A.M.	Air	35	Breeze; clear	Ripply	d	9
		Water	26.5				
7/12	10:55 A.M.	Air	32	No wind; clear	Smooth	d	9
		Water	27				
7/13	12:00 M.	Air	29.5	Wind; clear	Choppy	d	12
		Water	27				
7/14	10:30 A.M.	Air	26	No wind; clear	Smooth	d	9
		Water	26				
7/15	10:45 A.M.	Air	25.5	No wind; clear	Smooth	d	10
		Water	26				
7/16	10:45 A.M.	Air	28	Breeze; clear	Ripply	a	9
		Water	26				
7/17	10:45 A.M.	Air	30.5	Breeze; clear	Ripply	a	10
		Water	26				
7/18	2:00 P.M.	Air	32	Breeze; part cloudy	Ripply	a	13
		Water	26.5				
7/19	11:50 A.M.	Air	29	Breeze; hazy	Ripply	a	9
		Water	27				
7/20	10:00 A.M.	Air	26	Breeze; part cloudy	Ripply	a	9
		Water	26				
7/21	10:45 A.M.	Air	27	No wind; part cloudy	Smooth	a	9
		Water	26.5				
7/22	10:30 A.M.	Air	23	No wind; rain	Smooth	a	13
		Water	25				
7/23	10:30 A.M.	Air	27	Breeze; rain	Ripply	a	9
		Water	25				
7/24	10:30 A.M.	Air	26	Breeze; hazy	Ripply	a	9
		Water	25.5				
7/25	11:30 A.M.	Air	24	Breeze; part cloudy	Ripply	a	9
		Water	25				
7/26	12:30 P.M.	Air	26.5	Breeze; part cloudy	Ripply	d	9
		Water	26				
7/27	10:40 A.M.	Air	24.5	Breeze; clear	Ripply	a	13
		Water	25				
7/28	10:50 A.M.	Air	25	Breeze; hazy	Ripply	a	9
		Water	25.5				
7/29	10:45 A.M.	Air	25	Breeze; hazy	Ripply	a	9
		Water	25.5				
7/30	10:40 A.M.	Air	27.5	Breeze; hazy	Ripply	a	9
		Water	25.5				
7/31	11:00 A.M.	Air	26.5	Breeze; hazy	Ripply	a	9
		Water	26.5				
8/ 1	11:00 A.M.	Air	24.5	Breeze; part cloudy	Ripply	a	9
		Water	26				
8/ 2	11:07 A.M.	Air	27.5	No wind; clear	Smooth	a	9
		Water	26				
8/ 3	10:50 A.M.	Air	28.5	Breeze; hazy	Ripply	a	9
		Water	25.5				
8/ 4	10:30 A.M.	Air	27	Breeze; part cloudy	Ripply	a	9
		Water	25.5				

TABLE 9.—HOURLY COLLECTIONS, STATION III*a*

Date 1913	Time of first collection	Temperature centigrade		Air conditions	Water conditions	Anchor or drift	Number of hauls
8/11	7:00 A.M.	Air Water	19.5 24	Breeze; hazy	Ripply	d	6
8/11	8:00 A.M.	Air Water	20.5 24.5	Breeze; hazy	Ripply	d	6
8/11	9:00 A.M.	Air Water	22.5 25	Light wind; hazy	Wavy	d	6
8/11	10:00 A.M.	Air Water	24 25.5	Light wind; hazy	Wavy	d	6
8/11	11:00 A.M.	Air Water	27 26	Light wind; hazy	Wavy	d	6
8/11	12:00 M.	Air Water	28 26.5	Light wind; hazy	Wavy	a	6
8/11	1:00 P.M.	Air Water	29.5 26	Wind; hazy	Choppy	a	6
8/11	2:00 P.M.	Air Water	29.5 26	Wind; hazy	Choppy	a	6
8/11	3:00 P.M.	Air Water	30 26	Wind; hazy	Choppy	a	6
8/11	4:00 P.M.	Air Water	29.5 26	High wind; hazy	Rough	a	6
8/11	5:00 P.M.	Air Water	26 25.5	High wind; hazy	Rough	a	6
8/11	5:48 P.M.	Air Water	25.5 25.5	High wind; hazy	Rough	a	6
8/11	6:40 P.M.	Air Water	20.5 25	High wind; hazy	Rough	a	6

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(Owing to lack of time the writer is unable to present an exhaustive bibliography. Only those references are named in the following list which were most constantly in use, all of them being in the writer's immediate possession. The writer also made frequent use of the extensive private library of Professor C. A. Kofoid, as well as the library of the University of California.)

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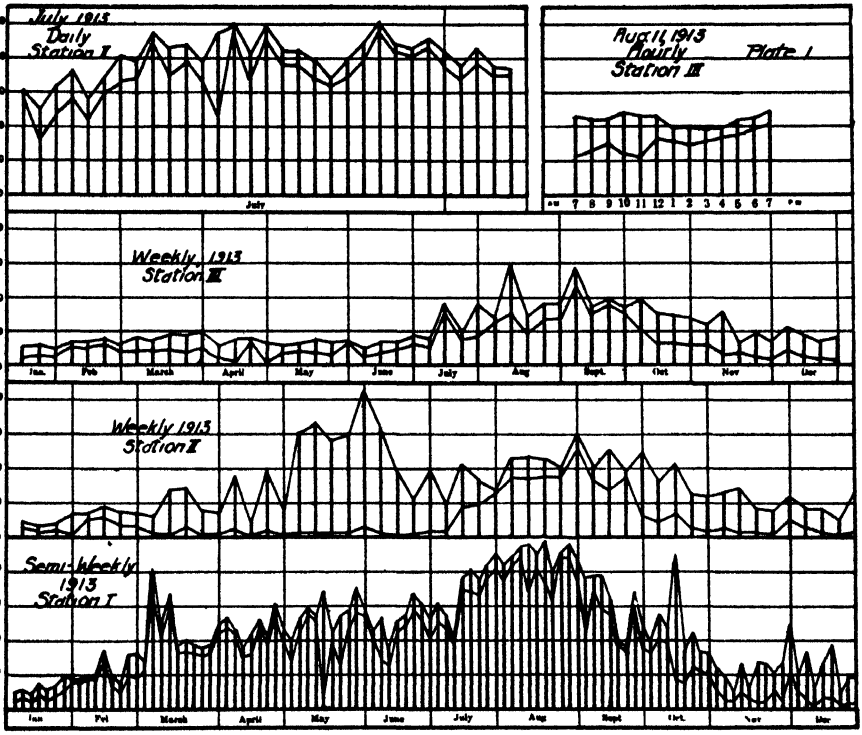

July 1913
Daily
Station I
July
Aug 11, 1913
Hourly
Station III
Plate I
AM 7 8 9 10 11 12 1 2 3 4 5 6 7 PM
Weekly 1913
Station III
Weekly 1913
Station II
Semi-Weekly
1913
Station I
0
10
20
30
40
50
Jan.
Feb
March
April
May
June
July
Aug
Sept.
Oct
Nov
Dec

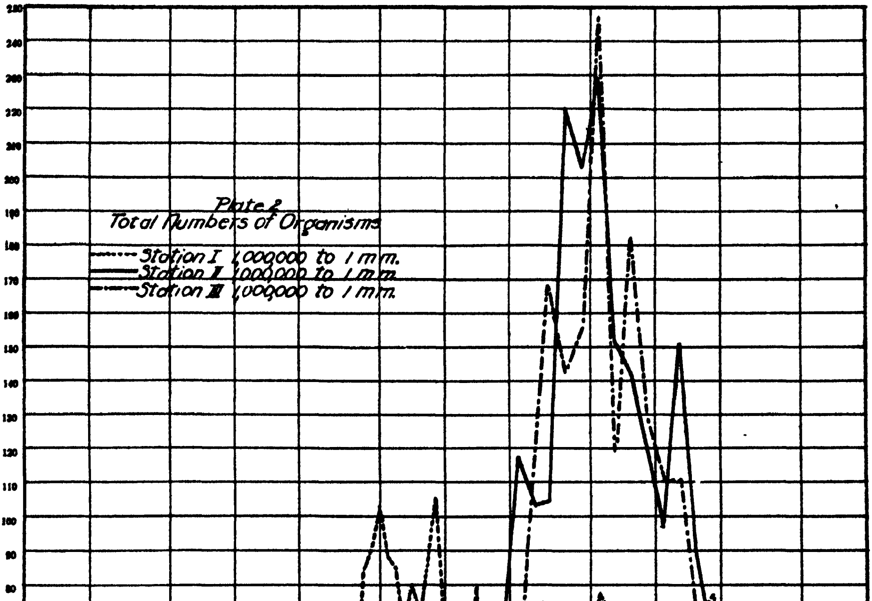


Plate 2
Total Numbers of Organisms
Station I 1,000,000 to 1 mm.
Station II 1,000,000 to 1 mm.
Station III 1,000,000 to 1 mm.
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan.
Feb
March
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

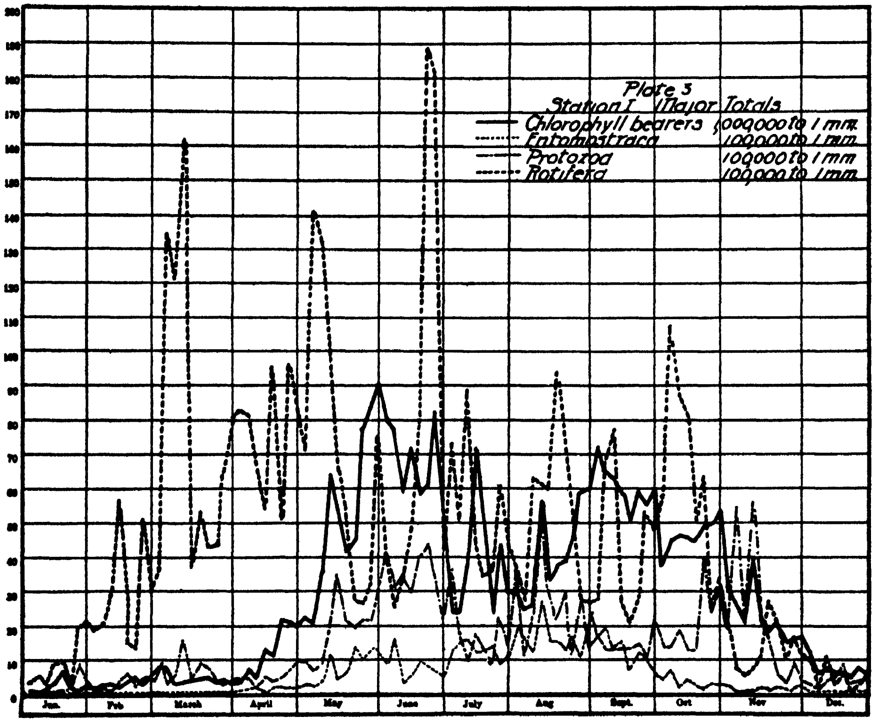


Plate 3
Station I Major Totals
Chlorophyll bearers 1,000,000 to 1 mm.
Entomostraca 100,000 to 1 mm.
Protozoa 100,000 to 1 mm
Rotifera 100,000 to 1 mm.
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan.
Feb
March
April
May
June
July
Aug
Sept.
Oct
Nov
Dec.

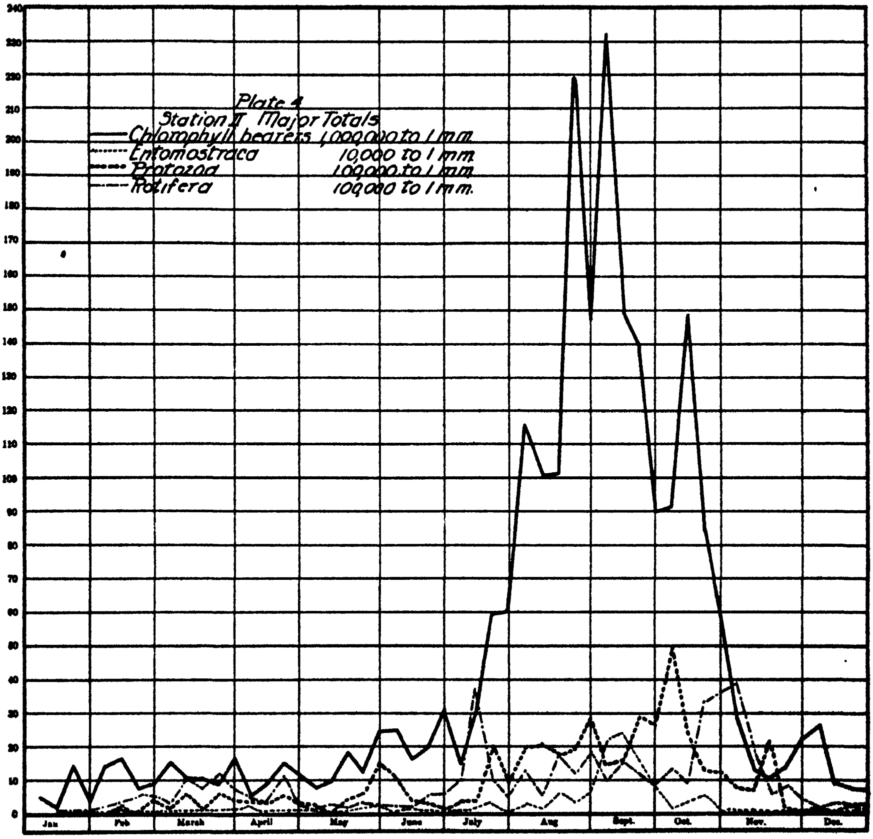


Plate 4
Station II Major Totals
Chlorophyll bearers 1,000,000 to 1 mm.
Entomostraca 10,000 to 1 mm
Protozoa 100,000 to 1 mm
Rotifera 100,000 to 1 mm.
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan
Feb
March
April
May
June
July
Aug
Sept.
Oct.
Nov.
Dec.

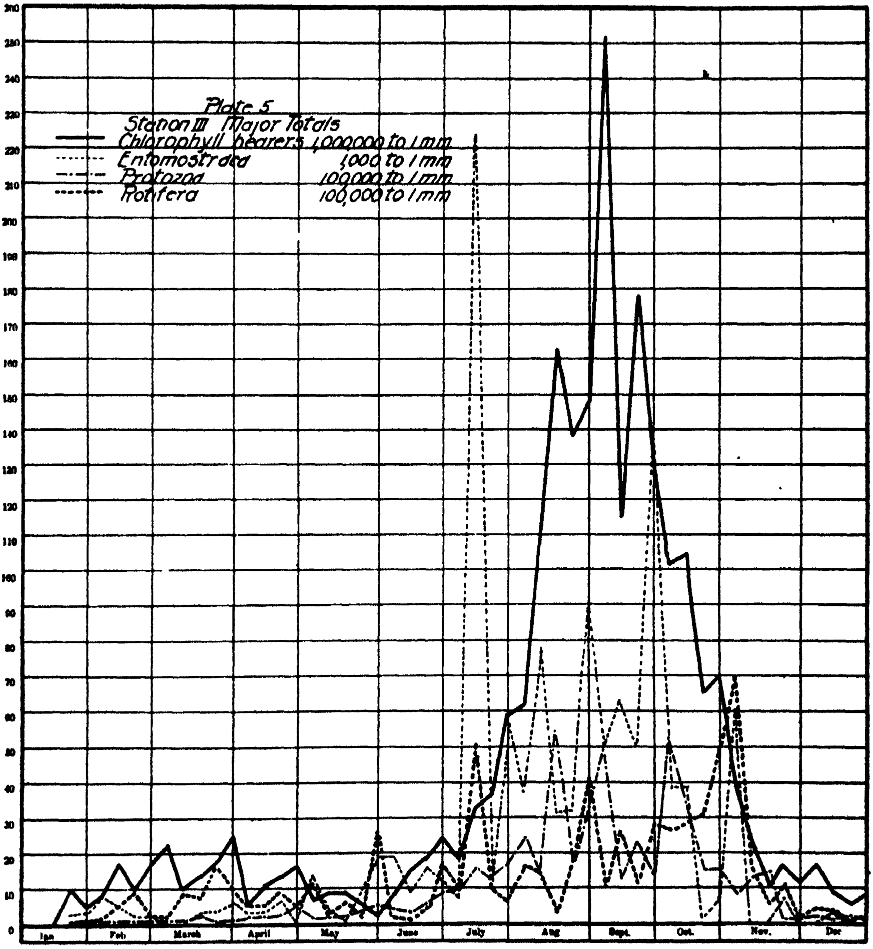


Plate 5
Station III Major Totals
Chlorophyll bearers 1,000,000 to 1 mm
Entomostraca 1,000 to 1 mm
Protozoa 100,000 to 1 mm
Rotifera 100,000 to 1 mm
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov.
Dec

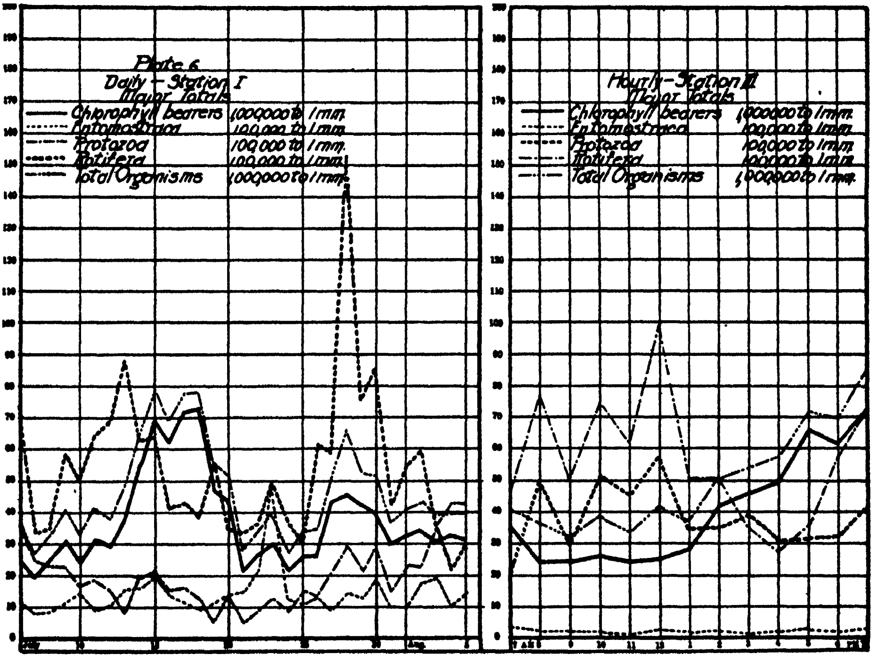


Plate 6
Daily – Station I
Major Totals
Chlorophyll bearers 1,000,000 to 1 mm.
Entomostraca 100,000 to 1 mm.
Protozoa 100,000 to 1 mm.
Rotifera 100,000 to 1 mm.
Total Organisms 1,000,000 to 1 mm.
Hourly – Station III
Major Totals
Chlorophyll bearers 1,000,000 to 1 mm.
Entomostraca 100,000 to 1 mm.
Protozoa 100,000 to 1 mm.
Rotifera 100,000 to 1 mm.
Total Organisms 1,000,000 to 1 mm.
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
July
10
Aug.
5
7 AM
8
9
10
11
12
1
2
3
4
5
6
7 PM

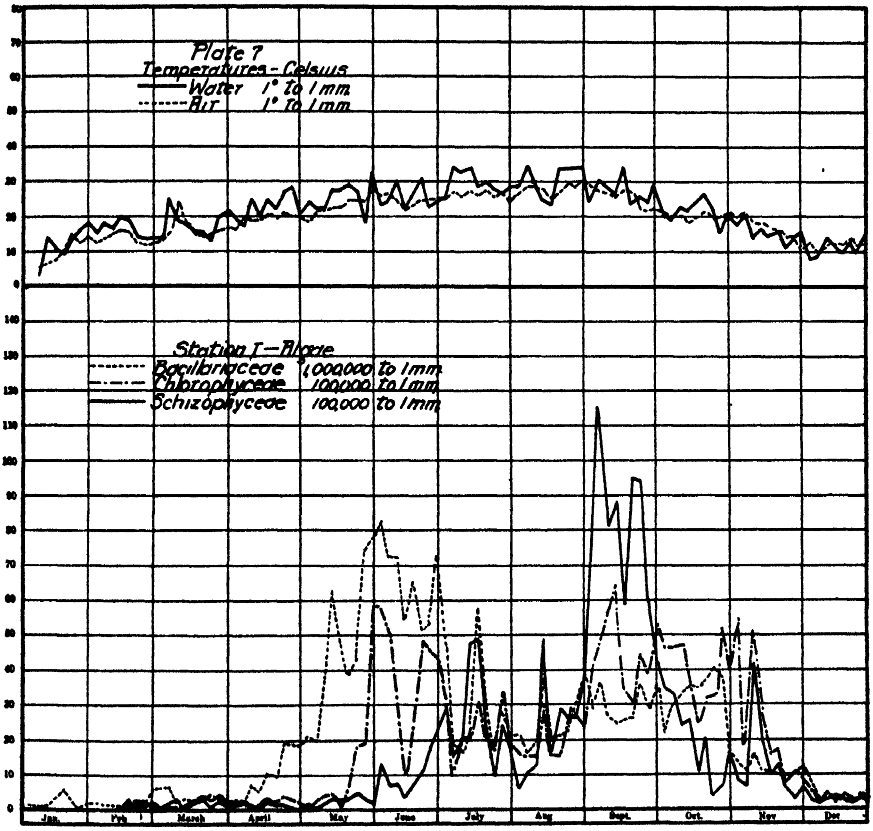


Plate 7
Temperatures - Celsius
Water 1° to 1 mm
Air 1° to 1 mm
Station I—Algae
Bacillariaceae 1,000,000 to 1 mm
Chlorophyceae 100,000 to 1 mm
Schizophyceae 100,000 to 1 mm
80
70
60
50
40
30
20
10
0
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan.
Feb
March
April
May
June
July
Aug
Sept.
Oct.
Nov
Dec

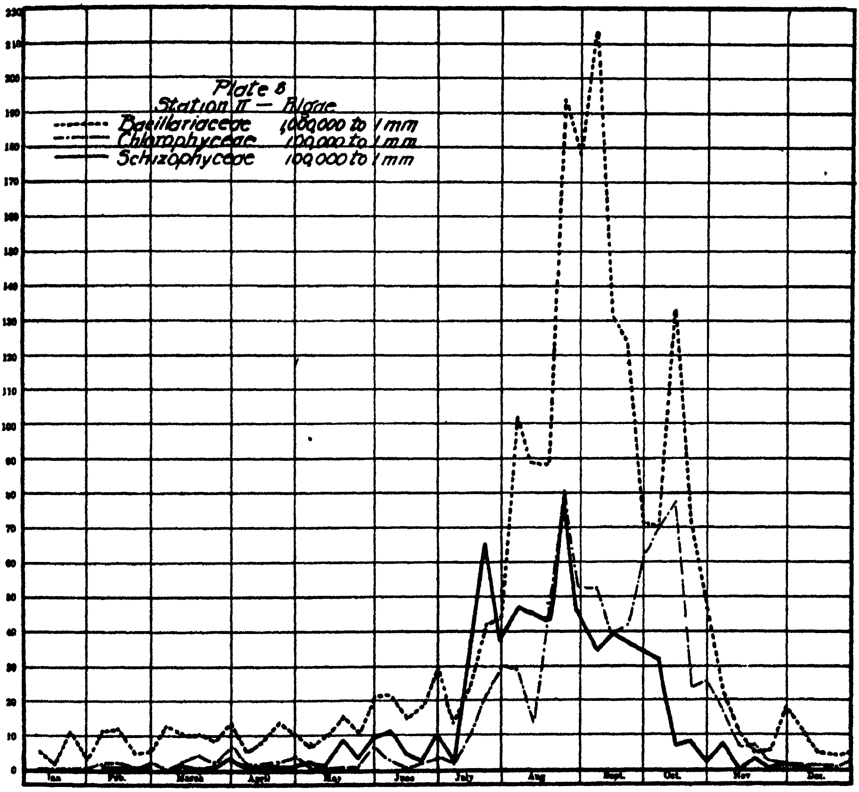


Plate 8
Station II — Algae
Bacillariaceae 1,000,000 to 1 mm
Chlorophyceae 100,000 to 1 mm
Schizophyceae 100,000 to 1 mm
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan
Feb.
March
April
May
June
July
Aug
Sept.
Oct.
Nov
Dec.

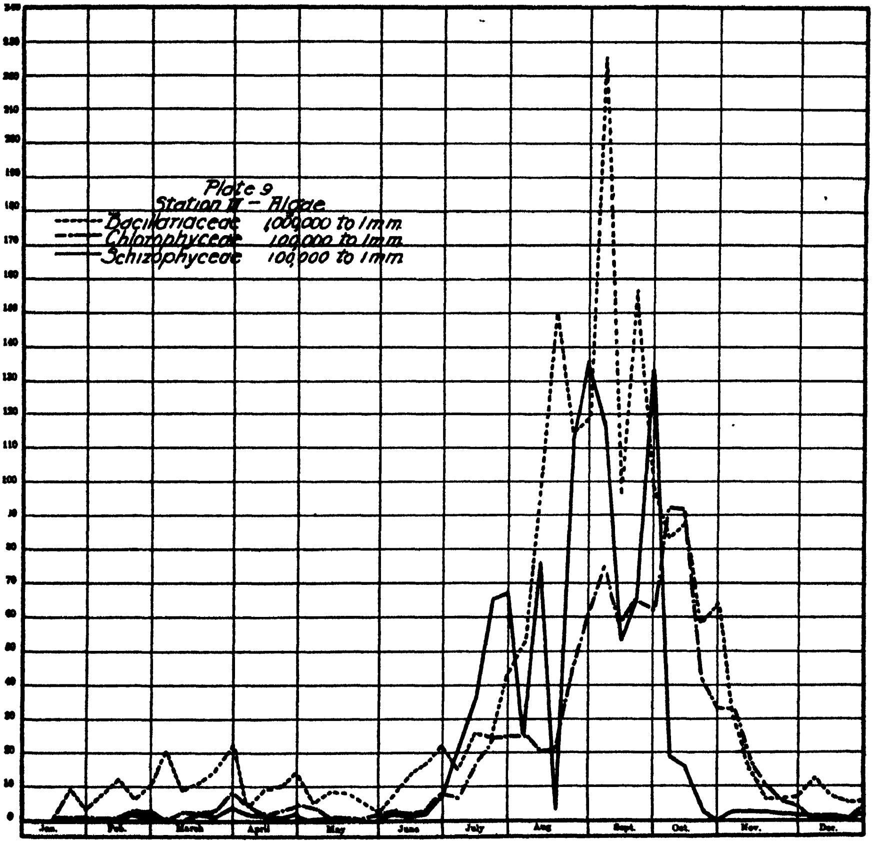


Plate 9
Station II – Algae
Bacillariaceae 1,000,000 to 1 mm
Chlorophyceae 100,000 to 1 mm
Schizophyceae 100,000 to 1 mm
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan.
Feb.
March
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

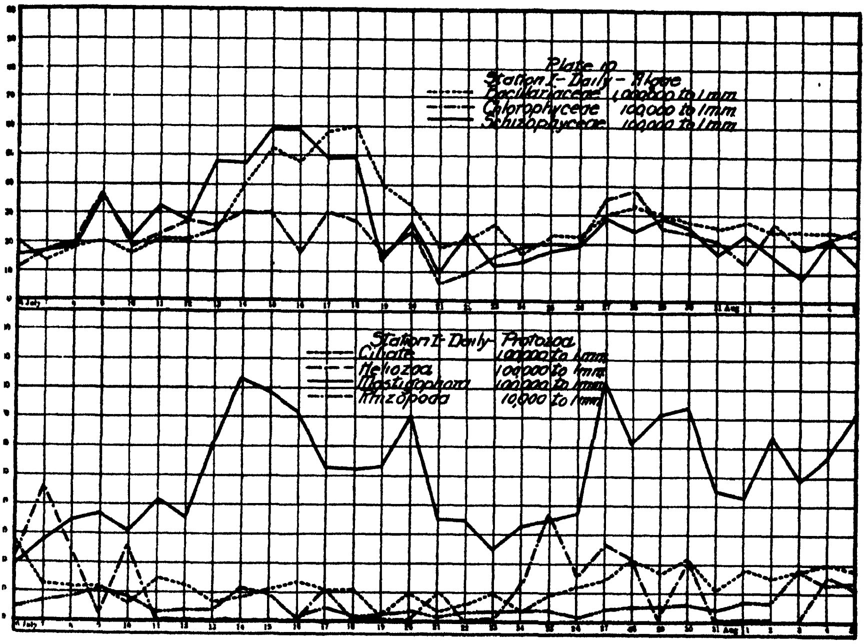


Plate 10
Station I – Daily – Algae
Bacillariaceae 1,000,000 to 1 mm
Chlorophyceae 100,000 to 1 mm
Schizophyceae 100,000 to 1 mm
Station I – Daily – Protozoa
Ciliata 100,000 to 1 mm
Heliozoa 100,000 to 1 mm
Mastigophora 100,000 to 1 mm
Rhizopoda 10,000 to 1 mm
July
Aug

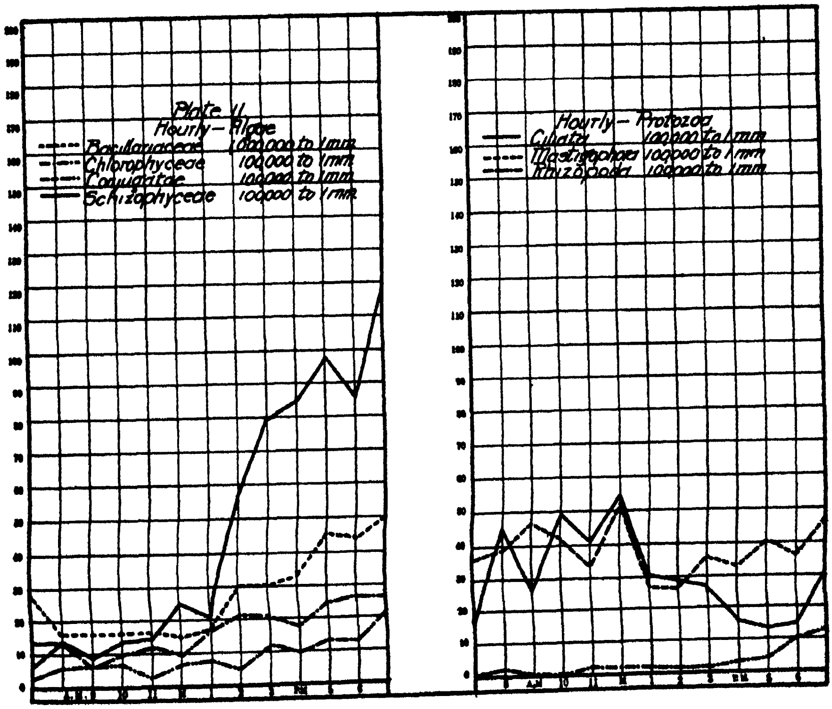
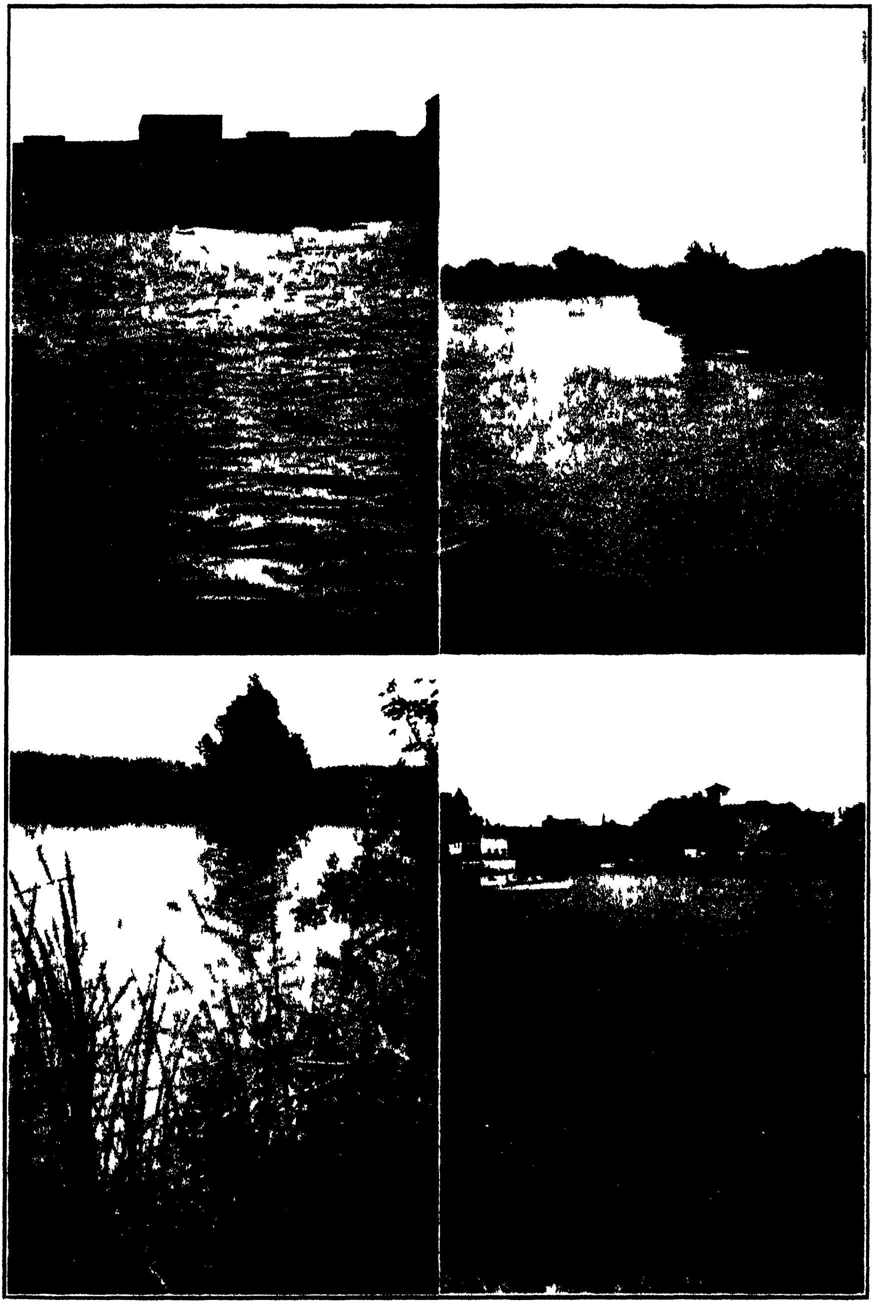


Plate 11.
Hourly – Algae
Bacillariaceae 1000000 to 1mm
Chlorophyceae 100000 to 1mm
Conjugatae 100000 to 1mm
Schizophyceae 100000 to 1mm
Hourly – Protozoa
Ciliata 100000 to 1mm
Mastigophora 100000 to 1mm
Rhizopoda 100000 to 1mm
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
A.M. 9
10
11
M
2
3
P.M.
5
6
9
A.M.
10
11
M
1
2
3
P.M.
5
6

Station I

Station II



Station III

Station IV

San Joaquin Plankton Collecting Stations

VARIATIONS IN THE SHELL OF TEREDO NAVALIS IN SAN FRANCISCO BAY

BY

ROBERT CUNNINGHAM MILLER

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INTRODUCTION

In investigating the activity of *Teredo navalis* in San Francisco Bay, it was early noted that this species presents locally a wide range of variation, particularly in the outlines and sculpture of the shell. At various points about the bay specimens were taken from time to time which differed so considerably in these respects as to suggest at least the possibility that they might represent distinct species. But further collecting continually brought to light intermediate forms, and, as these accumulated, they were found to link together the aberrant types by a large series of almost insensible gradations, so that there could no longer be any doubt that all were representatives of a single species. This species was identified by Kofoid (1921) as *Teredo navalis* Linn., and was shown in a later paper (Kofoid and Miller, 1922) to be identical with that species from European waters.

The present study has been undertaken with a view to pointing out the range of such variations under the conditions occurring in, San Francisco Bay, and, so far as possible, to correlate them with certain known factors of environment.

I am indebted to Professor C. A. Kofoid for invaluable direction and advice during the progress of this work. I am further grateful for the coöperation of the U. S. Lighthouse Service, the U. S. Navy Yard at Mare Island, the Board of State Harbor Commissioners, the Southern Pacific Railroad Company, the California and Hawaiian Sugar Refining Corporation, and the various members of the San Francisco Bay Marine Piling Committee, through whose assistance more than two thousand shells have been made available for our study.

The material at hand has been carefully worked over as a whole and certain selections with respect to age and locality have been made. The present paper represents a detailed study of about 800 shells.

THE SHELL OF TEREDO

DESCRIPTION

The shell of a larval *Teredo* at the time of its settlement on a submerged timber is that of a typical bivalve, nearly circular in outline, with prominent umbones. The valves are equal and extremely convex, so that together they have a subglobular form, this being characteristic of teredine larvae. A few lines of growth are indistinctly visible.

Very soon after settlement and the commencement of boring, however, marked changes become evident. Details of the metamorphosis are reserved for a later paper; suffice it to state here that the shell grows more rapidly at the ventral and posterior margins than anteriorly, so that the median portion becomes the most prominent part of the shell, while at the same time a pronounced wing or auricle is developed posteriorly, on the inner surface of which the large adductor muscle is attached. Because of the peculiar method of growth, a permanent gape is left between the valves both in front and behind; through the former of these protrudes the specialized subcircular foot, while through the latter the elongated body extends posteriorly.

A few days after the commencement of growth in the wood, the shell has assumed the form of the adult, in that each valve has a distinct anterior, a large median, and a posterior lobe. A knob or secondary point of contact early develops at the ventral edge of the median portion, so that the shells are able to rock on the original dorsal and secondary ventral articulations as fulcra, the anterior and posterior adductor muscles now opposing each other in action. The ridges on the anterior lobe are parallel to its margin, and meet at nearly right angles the prominently toothed ridges of the anterior part of the median lobe. Growth now occurs by addition of successive increments to the margin in such a way that the newly established shape of the shell is but little altered; each ridge on the anterior lobe meets at a right angle a ridge of the median lobe, which in turn is continuous around the ventral margin with a more or less prominent line of growth on the posterior portion. There is at the same time an increase in the thickness of the entire shell, owing to a further deposition of nacre on its inner surface, and in the region of the umbone a secondary calcareous plate, which conceals some of the earlier lines of growth, is deposited by the overlapping mantle.

In describing and referring to a shell so complicated in structure as this one, the nomenclature employed necessarily becomes somewhat involved. In order to render further discussion as lucid as possible, a ready key to the terminology employed is furnished in figure A. It will be observed that the three lobes of the shell are denoted respectively as anterior, median, and auricle. The second of these has been further subdivided into anterior median, middle median, and posterior median parts.

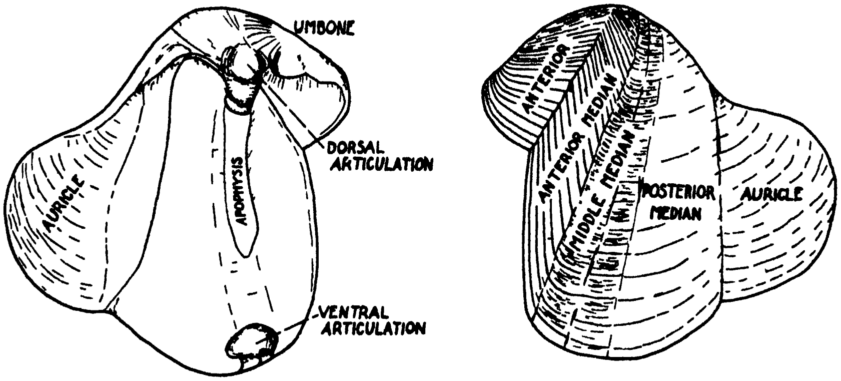

Fig. A. Interior and exterior views of the shell of *Teredo*, showing terminology adopted.

In interior view the salient features are the specialized dorsal and ventral articulations, and the broad, flat process extending free ventrally from the inside of the dorsal knob, the apophysis, the function of which is probably to yield visceral support.

Age and Depostion of Ridges

Morphologically the cutting ridges on the shell of *Teredo* are exaggerated lines of growth. Their deposition must be a function of two variables: a physiological tendency to deposit ridges with what seems to be an approximate periodicity, and a direct dependence of the activity of the animal upon conditions of food, salinity, and temperature. That is to say, the ridges on the shell are a record, not alone of the age of the animal, but also of the favorable or unfavorable conditions under which it has lived. To separate the effects of these two factors is a highly complicated problem.

By our system of planting and removing test timbers at regular intervals in infected localities, it has been possible to get a limited number of shells whose age can be estimated with a considerable degree of accuracy. These timbers, having been planted during the height of the breeding season, when the water was swarming with larvae, may safely be assumed to have been attacked within a few days after planting. As the seasonal period of attachment of larvae continues during several months, specimens of varying ages will of course be found in the same timber; accordingly, the larger specimens were selected in each case, as representing those which were first to enter the wood after it was placed in the water.

TABLE 1

RATE OF GROWTH OF RIDGES ON SHELLS OF TEREDO AT GOAT ISLAND

	Age			
	1 month	2 months	3 months	4 months
Number of ridges:	7	9	14	16
	8	11	15	16
	8	12	15	18
	8	12	15	18
	8	12	15	18
	8	12	16	18
	9	12	16	19
	9	12	16	19
	9	13	16	19
	9	13	16	19
	9	13	17	19
	9	13	17	19
	9	13	17	19
	9	13	17	19
	10	13	17	19
	10	14	17	19
	10	14	18	20
	10	14	18	20
	10	14	18	21
	10	14	18	21
	10	15	18	21
	11	15	18	21
	11	15	18	23
	11	15	18	24
	11	15	18	
	9.3	**13.1**	**16.7**	**19.3**

Rate of Growth per Month

1st month	2d month	3d month	4th month
9.3	3.8	3.6	2.6

Series of specimens of the ages indicated were available for comparative study from several localities in San Francisco Bay. The first group to be discussed is that from the lighthouse depot at Goat Island, in the central portion of San Francisco Bay. The ridges on the anterior lobe of the shell were counted under a magnification of 35 diameters. The results are given in table 1.

A source of error lies in the fact that, while new ridges are being added at the margin of the shell, certain of the earlier ones are lost by erosion or by the overgrowth of shelly material mentioned above, so that the figures in the table may represent a few less than the actual total of ridges deposited in a given time. This error seems unavoidable, and is negligible for practical purposes.

Data from older shells of known age are not available from this point, owing to the fact that our test timbers were greatly weakened at the end of the fourth month, and a heavy storm in December entirely destroyed them.

It will be noted that the rate of growth, as measured by addition of ridges, is extremely rapid during the first month (9.3), after which it drops suddenly and remains nearly constant during the next two months (3.8 and 3.6). This is what we should have expected from observing that the burrows of *Teredo* expand rapidly in the first inch or two of their length, after which the increase in diameter is slow and nearly constant. During the fourth month a further decrease (2.6) in the rate of growth is evident; this may indicate the influence of lowered temperature (the fourth month ended December 15) or the effect of crowding, as the timbers were already entirely honeycombed, so that further growth was much limited, if not indeed impossible.

At Goat Island we have a condition of high and fairly constant salinity, considerable depth (26 feet at low tide), and a minimum range of temperature fluctuation. Fortunately, we were able to make a comparative study (table 2) on material available from Crockett, a locality well toward the upper reaches of the bay. At this station the water is brackish and the temperatures more variable, owing to the inflow of a considerable volume of water from the San Joaquin and Sacramento rivers. The depth here is about the same as at Goat Island. Only specimens of the ages indicated were available.

Here again we note a rapid growth during the first month of boring life, followed by a sudden decrease, the figures for the first two months comparing markedly, both as to mean and to mode, with those tabulated for Goat Island. For the *progressive* decrease in rate of growth found at the end of the third month we find no explanation in external conditions. Salinity records are available for every day of this period, and show that the salt content of the water, while fluctuating considerably, never fell below 12 parts per 1000, and was usually above 20 parts per 1000; being, in fact, at its highest during the period when the decrease in rate of growth occurred. Our experimental work has indicated that *Teredo* will flourish in salinities considerably lower than these. The only explanation, therefore, which recommends itself is that suggested above in connection with a similar

TABLE 2

Rate of Growth of Ridges on Shells of Teredo at Crockett

	Age			
	1 month	2 months	3 months	6 months
Number of ridges:	6	10	12	18
	7	10	12	18
	7	10	13	18
	7	10	13	18
	8	11	13	18
	8	11	13	18
	8	11	13	18
	8	11	13	19
	8	11	13	20
	9	12	13	20
	9	12	14	20
	9	12	14	21
	9	12	14	21
	9	12	14	21
	9	13	14	21
	9	13	14	22
	9	13	15	22
	10	13	15	22
	10	13	15	22
	10	13	16	22
	10	14	16	23
	10	14	16	23
	10	14	16	24
	11	14	16	24
	11	14	17	26
Mean:	8.8	12.1	14.2	20.7

Rate of Growth per Month

1st month	2d month	3d month	4th, 5th and 6th months (mean)
8.8	3.3	2.1	2.2

finding at Goat Island, namely, the deleterious effects of crowding. Our experimental timbers at Crockett were so thoroughly riddled after three months that they went to pieces, and no further data were obtained from them.

It should be explained that the six months specimens were taken from heavier timbers, which were not so soon destroyed.

A few shells of known age were available from other localities, and these were examined as a check on the accuracy and general applicability of the above figures. From the Oakland Harbor Light Station, two miles across the channel from Goat Island, 5 shells 3 months old averaged 16 ridges; 8 shells 4 months old averaged 18.7 ridges. From the Dumbarton bridge of the Southern Pacific Railroad, near the southern end of the bay, a series of 10 shells 6 months old averaged 20.5 ridges. From the dock of the Angel Island Immigration Station, a series of 10 shells of similar age averaged 20.6 ridges. These findings, with due allowance for the smaller numbers considered, are in general agreement with the foregoing tables.

As to the rate of deposition of ridges after 6 months, no precise data are available. A series of 25 shells from Crockett, estimated from the length of the burrows and the period of time the pile from which they were taken was known to have been exposed to be not less than 15 months old, averaged 38.8 ridges. A series of 20 shells from Goat Island, judged to be of approximately the same age, averaged 42.1 ridges.

The largest shell which we have taken has 81 ridges. This shell is from a specimen 20 inches long taken at the Oakland Southern Pacific Mole, which, from its size, the thickness of the nacre lining the burrow, and the badly worn condition of the pallets, may very well be two years or more old.

While we would hesitate to draw any sweeping conclusion from a study of only 270 shells of approximately known age, the data appear certainly to justify the statement that, under the conditions of salinity and temperature occurring normally in San Francisco Bay, with some exceptions later to be discussed, the shell of *Teredo navalis* may be expected to grow at the rate of 8 or 9 ridges during the first month of boring life, and from 2 to 4 ridges per month thereafter.

It will be noted that the tables show a slight but consistent advantage in number of ridges of the shells from Goat Island over those from Crockett. The significance of this fact will be pointed out farther on.

VARIABILITY AND ENVIRONMENT

There is scarcely a detail of the structure of a *Teredo* shell which does not exhibit variability. The outlines of the shell and the relations of the various parts to each other are frequently markedly dissimilar in different specimens. This is particularly true with reference to the auricle, which may be reduced or very prominent, rounded or quadrate, or elongate and reflected; its position varies between posterior and posterodorsal. Other marked variables are the prominence of the ridges on the anterior and median lobes and the width of the spacing between them, details of the serrations on these ridges, width of the anterior median denticulated area, size of the angle formed at the junction of anterior and median lobes, degree of convexity of the shell, and thickness and color of the periostracum. On the interior of the shell, considerable variation occurs in the relative length and breadth of the apophysis, and in the width of the shelf produced by the slight overlapping of the inner edge of the auricle upon the median portion.

To treat in detail of all the deviations observed in these studies would be a practical impossibility, as well as inconsistent with our limited knowledge of the conditions which occasion them. We have accordingly confined attention to those variations which are at once the most salient and the most easily described or expressed in terms of numerical coefficients. Such are the variations occurring in numbers of ridges, in length of auricle, in certain details of surface sculpture, and in color. These will be considered in the following pages in relation to what seem to be their principal environmental antecedents.

Ecological Conditions

San Francisco Bay exhibits a series of conditions of peculiar interest from an ecological point of view. As regards salinity, depth, and temperature, and somewhat, as well, the contour of the shore, the bay naturally divides itself into three major portions, which we may term according to geographical position "upper," "middle," and "lower." The upper bay includes San Pablo and Suisun bays and the connecting straits (see map, pl. 13), being bounded on the south by a line from Point San Pedro to Point San Pablo. The middle bay extends from this line southward to "a line through the

[San Francisco] Ferry Building and Goat Island Light" (Sumner, *et al.*, 1914, p. 22). The lower bay includes the remaining portion south of this line.

These three divisions, taken as a whole, manifest three rather distinct sets of ecological conditions.

The upper bay represents the brackish water environment, with continually fluctuating salinity and maximum range of temperature throughout the year. Receiving at its upper end the combined discharge of the Sacramento and San Joaquin rivers, this segment of the bay is very greatly affected by the inflow of so considerable a quantity of fresh water. The interaction of run-off and tidal movement produces a daily and almost hourly change in salinity, which is altered further by variations in the width and depth of the channel at different points, and by differences in the seasonal discharge of the rivers, which is ordinarily more than five times as great during the first six months of the year as during the last six months (Grunsky, 1921, p. 14, etc.). In the Carquinez Straits the annual range of variation in salinity is as great as from 0 to 27 parts per 1000. Salinities at several points in the upper bay during 1921 are graphically shown in the appended chart (fig. B).

The middle bay exhibits a set of conditions nearly the opposite of those just described. Its greater depth and volume and proximity to the open sea make for a condition of high and fairly constant salinity and for a minimum temperature fluctuation. Salinities at two localities in this portion of the bay during 1921 are charted in figure B. These are not, unfortunately, the localities of maximum salinity, being considerably to the northward of the Golden Gate. Records of the *Albatross* investigations during 1912–1913 show the mean annual salinity at certain points in this area of the bay to be as high as 30 and even 31 parts per 1000 (Sumner, *et al.*, 1914, pl. 4).

The lower bay represents an environment intermediate between the two extremes just described. A great unbroken expanse of comparatively shallow water (mean depth 7.8 fathoms, as compared with a mean depth of 14.8 fathoms for the sector of the bay between Goat Island and Point Richmond), receiving no streams of any importance, the lower bay presents a complex of conditions peculiar to itself. The salinity is somewhat lower than that of the waters more proximal to the open sea, though at the same time it probably is subject to less daily and seasonal variation. Unfortunately, hydrographic investigations in this region have been extremely limited. The *Albatross*

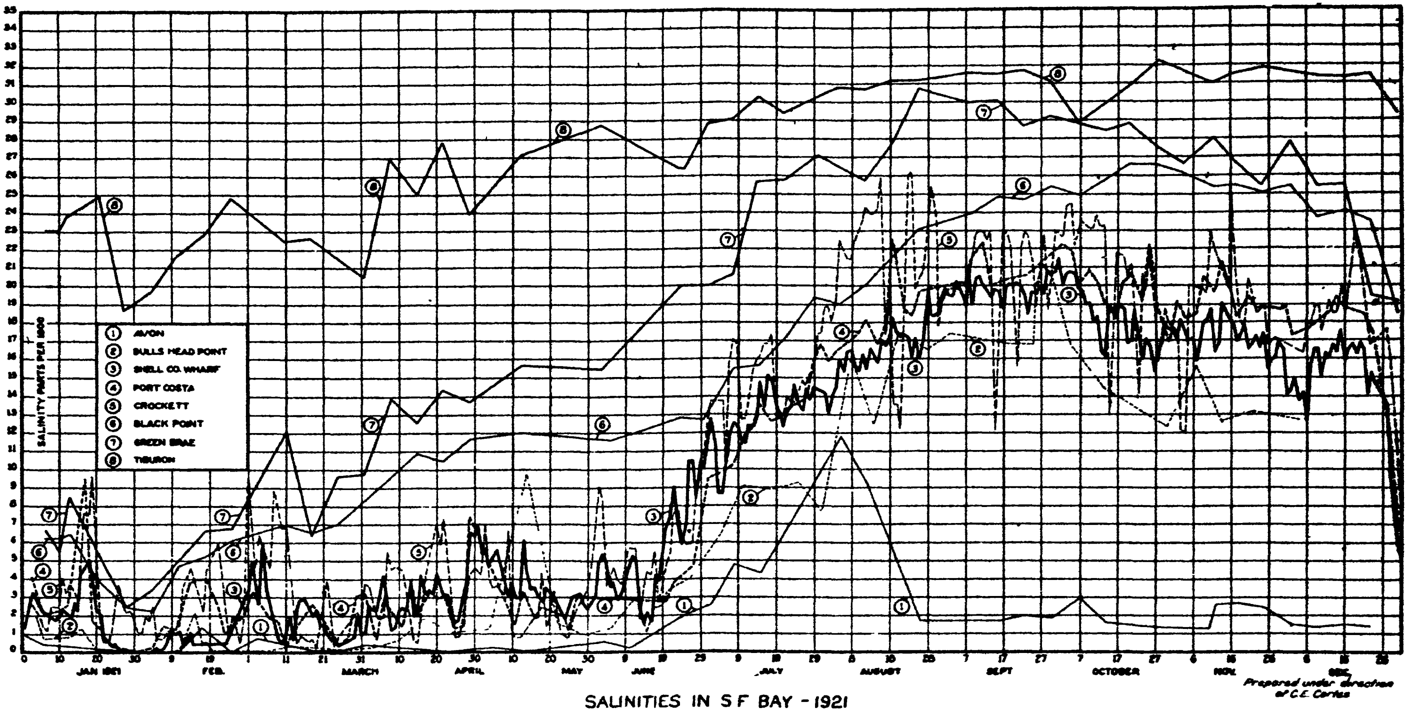

Fig. B. Salinities at various points in San Francisco Bay during 1921. Stations 1–6 are in the upper bay, 7–8 in the middle bay. Reproduced by courtesy of the San Francisco Bay Marine Piling Committee from its Report for 1922.

records show a mean salinity of from 28.47 to 29.14 at eight different stations south of Goat Island, the lowest figure recorded during a one-year period being 24.85 as compared with a maximum of 31.36 at the same station. For a very large stretch of water at the southern end of the bay no salinity records are available, but we are fairly safe in assuming that they would be consistent with the above figures, with *possibly* a slight increase in the mean during the summer, owing to the effect of evaporation[1] (Sumner, *et al.*, 1914, p. 85), and the opposite effect of seepage during and after the maximum run-off.

The temperature range is notably greater here than in the middle bay, owing largely to the influence of air temperatures on so large an expanse of relatively shallow water; but less, on the other hand, than in the upper bay, whose temperatures depend in considerable measure on those of the rivers tributary to it.

Temperature ranges in the three divisions of the bay can best be compared by reference to text figure C, where they are graphically represented.

Depth is a factor which we have usually not taken into account; this will be briefly discussed farther on. The effect of sewage (oxygen content) has also been disregarded, owing to the difficulty of obtaining quantitative data; in this connection it is to be remembered further that the greatest sewage contamination occurs in the middle bay, where volume of water and tidal action are greatest, both tending to counteract the effect of sewage; if contamination of this sort has any influence on *Teredo,* such influence probably occurs only actually at or near the mouths of sewers.

In order that any effect of environment in producing variation might be observed in its maximal expression, we selected for this

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[1] A few water samples taken at scattered intervals at Dumbarton by the writer suggest that salinities at this point are not so high as Sumner (*loc. cit.*) has supposed. Below are tabulated our findings, together with salinities on or near the same dates at Tiburon, in the middle bay. It will be seen that the figures for the latter station are notably higher, even though Tiburon is not a locality of maximal salinities in this sector of the bay.

COMPARISON OF SURFACE SALINITIES AT DUMBARTON AND TIBURON DURING THE SUMMER OF 1922

DUMBARTON			TIBURON		
Date	Tide	Salinity	Date	Tide	Salinity
May 24	high	22.18	May 26	high	22.81
July 21	high	28.57	July 21	high	29.51
Aug. 24	low	26.51	Aug. 25	low	29.51
Aug. 28	low	27.77	Sept. 1	low	31.06
Sept. 8	middle	28.53	Sept. 8	low	31.71

The samples at Dumbarton were taken in the main channel, where the depth is about 50 feet, and the tidal flow very great. It does not appear that evaporation has had any appreciable effect in increasing salinities in this region during the period in question, unless it be in very shallow slack water along the shores.

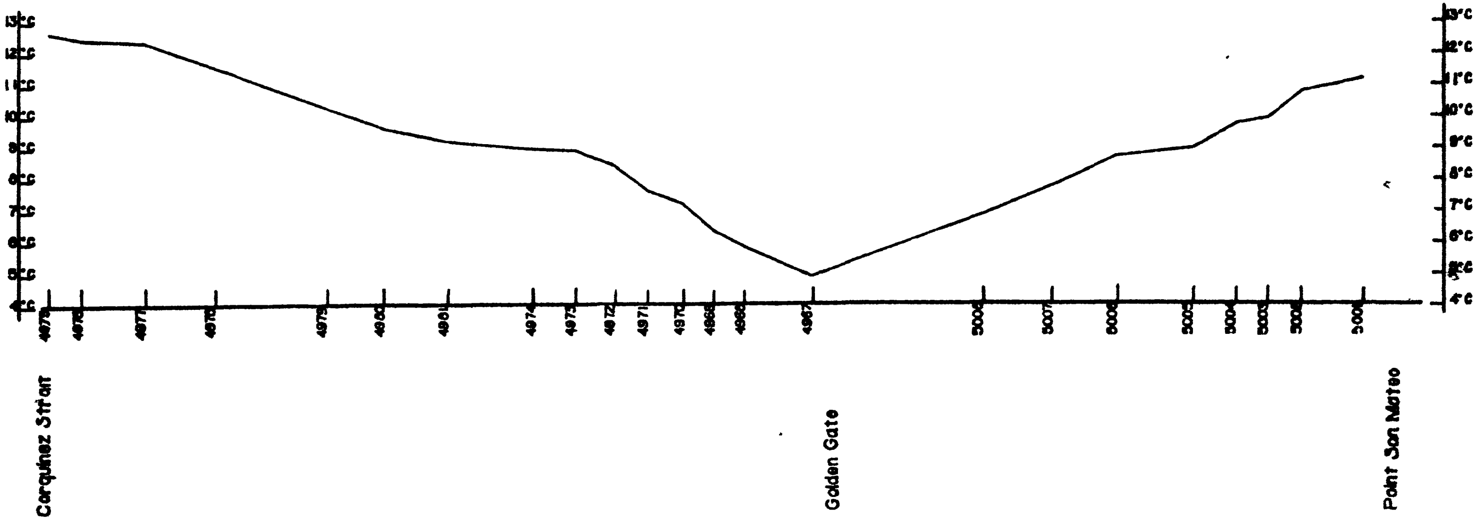

Fig. C. Seasonal range of temperature in the three divisions of the bay. Numbers along the locality coördinate refer to hydrographic stations. (After Sumner, et al., 1914, fig. C.)

study specimens of *Teredo* from localities most distinctly characterized by the physical differences we have described. Specimens from the upper bay have been taken principally from the region of Carquinez Straits, those representing the middle bay from Goat Island and from the Southern Pacific and Western Pacific moles, and those considered typical of the lower bay have been collected at Dumbarton.

VARIATION IN NUMBER OF RIDGES

It has already been pointed out, in discussing the growth of the shell, that shells from Goat Island show a slight but consistent advantage in number of ridges over shells of the same age from Crockett. The significance of this was not immediately evident. In order to let further light on the matter, it was decided to count on several series of shells *the number of ridges per millimeter* on an arbitrarily chosen part, in order to determine whether or not there is actually *a greater number of ridges per unit area* on the shells from the middle bay. The portion of the shell chosen was the first millimeter of the anterior median denticulated area, approximately in a line with the lower edge of the anterior lobe, but definitely at right angles to the ridges. The following curves (Fig. D) are based on 50 shells from each of three localities; the shells have been selected at random, but are not the same ones used in preparing the above tables of rate of growth, which makes the correspondence in results the more significant.

These curves appear to indicate a very definite correlation between environmental conditions and the number of ridges per unit area on the shell, the greatest number of ridges being found on shells from the middle bay, and the least number on shells from the upper bay, while those from the lower bay stand intermediate between them. The exact reason for this correlation is not entirely clear. We would suggest that it lies both in the absolute differences in temperature and salinity and in the range of such differences.

That environmental conditions play a prominent part in determining the deposition of ridges there can be no doubt. We are often able to read in the sculpture of a series of shells from a given locality the history of some definite alteration in the life conditions, which has left its mark on a number of shells. As an example of this, note in plate 14 the unusually wide interspace by which the newest ridge is separated from its neighbors, this same condition occurring in a number of shells taken at the same time and place.

With the foregoing facts in mind, we naturally infer that the combination of conditions occurring in the upper bay tends to produce certain changes in the physiological cycle of ridge deposition, the net result of which is a lesser number of ridges per unit area of the shell than we find to be the case under the conditions prevailing in the middle and the lower bay. This corresponds with the results of tables 1 and 2, which indicate *a fewer number of ridges per unit of time* for shells from the upper bay. That is, in the Carquinez Straits region, *Teredo* deposits ridges farther apart and at wider intervals of time than at stations down the bay.

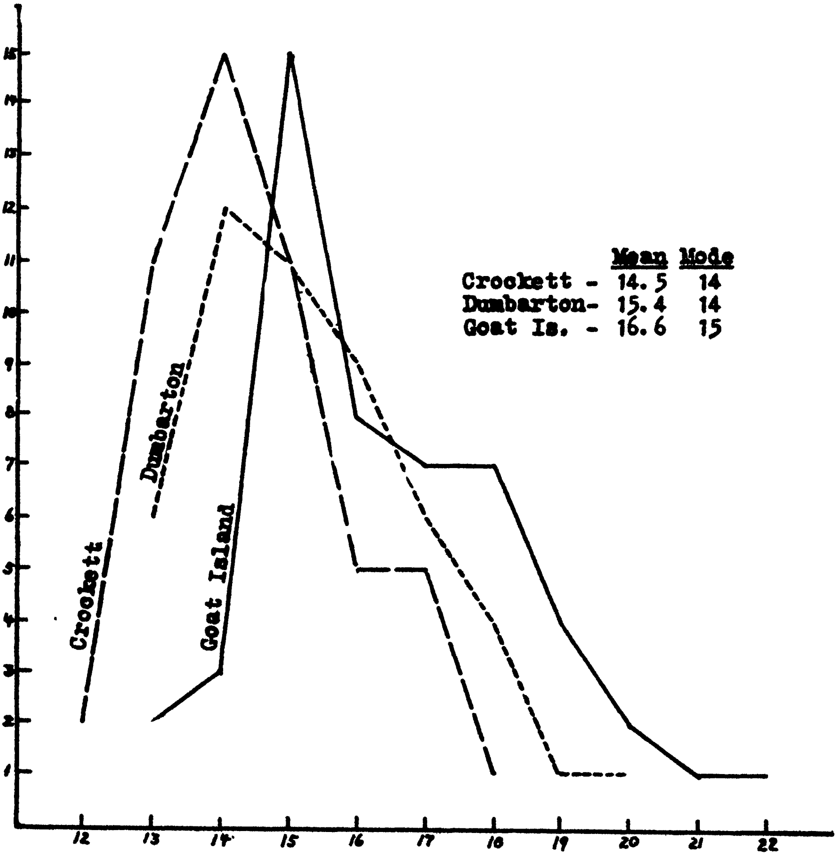

Fig. D. Curves showing number of ridges per millimeter on the shell of *Teredo* from three different stations.

A further note of interest on the effect on *Teredo* of lowered salinity and fluctuating temperature is the difference to be observed between shells at different levels of the same pile in the upper bay.

This is well brought out in plate 15, figure 1, where we have compared a series of shells taken at Crockett from near the mud line of a pile (depth 20 feet) with a series from near the top of the same pile, taken at about low tide level. Our hydrographic data show that the differences between top and bottom salinities at this point, owing to the greater specific gravity of the more saline water, may at times be as great as 6 parts per 1000 (Kofoid and Miller, 1922, p. 81). We know further that in this location conditions sometimes prove lethal to *Teredo* near the top of a pile, while permitting it to survive lower down. In other words, the surface conditions here are very close to the critical point which determines the life or death of the animal.

The shells of *Teredo* occurring in this region of stress at the upper end of the pile are very notably dwarfed as compared with those from a greater depth. Furthermore, they have fewer ridges, and the interspaces separating these are considerably wider (pl. 15, figs. 1, 2 and 3). These facts are entirely consistent with our previous conclusions regarding the effect of lowered salinity and fluctuating conditions, being merely an exaggeration of the differences found between shells from Crockett and Goat Island.

It is to be remarked also that shells from near the surface at Crockett are very similar to shells from near the bottom at Port Costa and Martinez, points farther up the bay, where *Teredo* leads a precarious existence and rarely survives the fresh-water period of winter floods.

Under these unusual conditions the estimate of the rate of growth of the shell of *Teredo* set down above (p. 300) would not hold good, growth being much retarded.

Elsewhere in the bay the effect of depth has not been taken into consideration, owing to a paucity of material from near tide levels. A few specimens that we have from the upper part of a pile in the middle bay are not observably different from those taken at greater depths. Conditions at surface and bottom are much more uniform in the middle and the lower bay, and any effect of depth is probably so slight as to be negligible.

VARIATION IN THE AURICLE

Inasmuch as the variations which occur in the posterior lobe of the shell are rather obvious to the eye but extremely difficult adequately to describe, considerable care has been given to the preparation of plates 16 and 17 (fig. 1) in order that they may illustrate as accurately as possible the range of the differences we have observed.

The position of the auricle, we have noted above, varies between posterior and posterodorsal. It was at first thought that this might have some definite significance with relation to the effect of environmental factors; but further study has indicated that the position of this lobe of the shell is in considerable degree determined by the age of the specimen. In younger shells the auricle is normally posterodorsal; but as it grows by further accretions backward and ventrally, it is *resorbed at the dorsal edge,* so that its position with reference to the median part of the shell becomes continually more definitely posterior. This is strikingly illustrated in plate 15, figure 4.

With regard to the degree to which the auricle is reflected outward at its posterior edge, a condition which becomes more exaggerated in the older shells, it is sufficient to remark that this is an adaptation to prevent its cutting into the viscera with the rocking movement of the shell which accompanies boring; naturally this condition becomes more pronounced in those shells having the longer auricles.

Shells from the upper bay tended in general to have more prominent auricles than shells from the middle and the lower bay. We undertook, accordingly, to get a definite numerical expression of the degree of this difference. The greatest length of the auricle (measured outside, from the depression which marks its junction with the middle lobe to its posterior edge) was divided by the length of the middle lobe, as measured on a line taken from the angle between anterior and middle, perpendicular to the forward margin of the middle (fig. E). The resulting quotient was taken as the index of the relation of the auricle to the middle lobe. These indices were then tabulated and used as the basis of a graphic representation of the range of the differences in question.

The length of the middle lobe was taken as a constant somewhat arbitrarily, not because it does not vary, but for convenience, and because it was deemed a safer constant than, for example, the entire length of the shell, which would include the possibility of an independent variable in the anterior lobe.

We would mention further that measurements based on the *length* of the auricle give an inadequate representation of the actual range of variation encountered; variation occurs, also, as we have previously stated, in *breadth* and in *shape* (pl. 16); but it is difficult, for obvious reasons, to reduce these factors to a numerical expression. We have for practical purposes considered simply the *prominence* of the auricle, and of this the measured length gives us a fair indication.

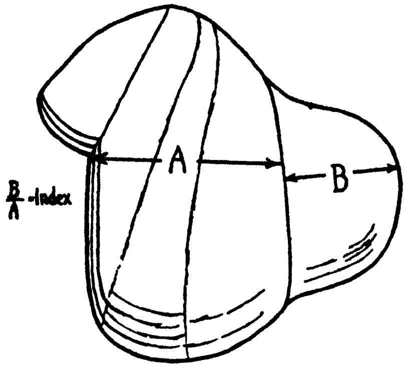

Fig. E. Diagram of *Teredo* shell, showing method of obtaining index of auricle.

The following graphs (Fig. F) are based upon 100 shells from each of the three localities selected.

In analyzing these curves, we observe first a constant and rather marked difference between shells from Goat Island and those from Crockett, a difference which is expressed alike in the extremes, the means, and the modes. The shells from the upper bay have a definitely and consistently larger auricle than those from the middle bay. The shells from Dumbarton, as we should have anticipated from our analysis of environmental conditions at that place, stand intermediate between those from the upper and the middle bay. While all three of our curves manifest certain irregularities, owing doubtless to the limited number of shells considered, at seven points out of a possible eleven the curve representing shells from the lower bay falls between the other two.

The most salient feature of these graphs is the closeness with which they agree with the graphs representing the number of ridges per millimeter of the shells from the same three localities (fig. D). While the relation is indeed an inverse one, it indicates none the less the consistent action of environment in producing variation. In other words, we have studied these groups of shells from two entirely different points of approach, and have arrived in each case at the same conclusion, namely, that the three different types of environment have produced three rather distinct types of variation in the shell of *Teredo,* and that in each case the intermediate environment (the lower bay) has produced a type intermediate between those of the middle and the upper bay, representing the extremes of environment.

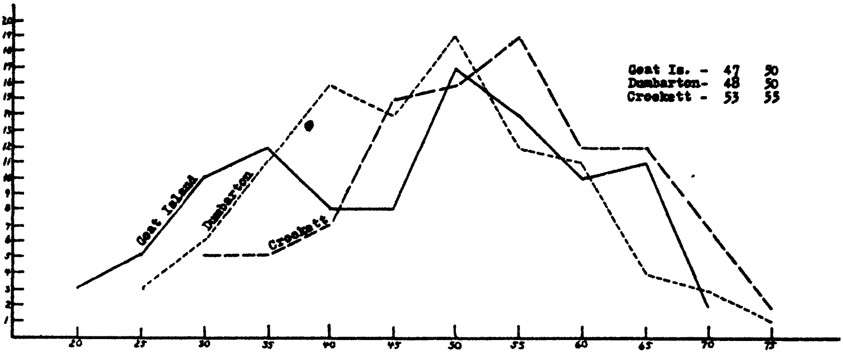

Fig. F. Curves representing index of auricle of the shell of *Teredo* at three different stations.

VARIATION IN SURFACE SCULPTURE

Shells from the upper bay are generally more irregularly sculptured and rugose than those from other portions of the bay. They are less transparent and lustrous; the periostracum is thicker and more opaque, and considerably roughened across the middle median area. The lines of growth are more prominent, indicating greater lapses in the process of growth than occur under the more constant conditions of the middle bay.

It has already been shown that the denticulated ridges are less numerous and closely spaced on shells from the upper bay than on those from the middle and the lower bay. A microscopic study shows that these differences are carried even to the details of the denticles on the ridges. On the shells from the upper bay, with their fewer and more widely spaced ridges, these denticles are more individuated and sharply outlined, having a distinctly serrate appearance (pl. 17, fig. 4). Shells from the middle bay, on the other hand, have more close-set and less sharply delineated denticles, which, under the low power of the microscope, present a beadlike appearance, very different from that just described (pl. 17, fig. 2). Here once more we find that shells from the lower bay occupy a position intermediate between the other two types (pl. 17, fig. 3), with a tendency to resemble more nearly the form from Goat Island.

VARIATION IN COLOR

The shells from Crockett (see plate 16) are very distinctly more pigmented than those of either of the other series. This is true of shells from the upper bay generally; we have found it to be the case almost without exception in shells from Mare Island, Crockett, Port Costa, and Martinez, as compared with shells from Goat Island, Angel Island, Oakland Harbor, and the San Francisco water front.

Coloration when present ordinarily manifests itself chiefly in a fairly broad brownish stripe from dorsal to ventral across the middle median portion. This stripe varies in color from a pale brownish yellow through varying shades of brown, often warmly tinged with red, to a heavy sepia; the color nearly always tends to fade out toward the dorsal and ventral margins of the shell. In addition to this median stripe we often find, more especially in shells from the upper bay, a roseate or occasionally brownish color suffused over the denticulated area (anterior median); in the more heavily pigmented shells a distinctly reddish or brownish patch occurs on the auricle.

As regards the absolute differences of coloration in shells from the upper and the middle bay, it is difficult to make any statement more definite than that the former manifest color in maximal, the latter in minimal, amount. Shells from the upper bay are characteristically marked with reddish or brownish color, while those from the middle bay are lighter and more translucent, and often entirely white. The Dumbarton shells more nearly resemble, in this respect, those from the middle bay.

With our present limited knowledge of the physiology of *Teredo*, the basis of these differences in color is difficult to determine. The color lies entirely in the periostracum, which may be scraped off, leaving the shell perfectly white. This would suggest that the thickness of the periostracum is at least a factor in producing depth of color. It has been stated above that the shells from the upper bay exhibit a thicker and rougher epidermis; it is natural therefore that these shells should have the deepest color, while those from the lower bay would be lighter, owing to the white prismatic layer showing through the thinner epidermis.

That coloration is, however, in considerable measure directly dependent on immediate factors of environment, independent of the thickness of the periostracum, becomes evident from certain types of what we may term "accidental" coloration that have been occasionally observed.

In two different instances we have found that a nail driven into a redwood timber below water line has produced an area of black discoloration (ferric tannate) through the action on the iron of the tannic acid in the wood. Teredos were working successfully in this discolored area, but their bodies and shells were deeply stained with blue (pl. 17, fig. 6). Teredos working elsewhere in the same piece of wood were not so colored.

In a number of instances we have found that the shells of *Teredo* left in stagnant water in our aquaria were colored almost entirely black by the action of sulphur bacteria (pl. 17, fig. 5). This must have been due to some physiological cause, as the shells of dead teredos under the same circumstances were not discolored.

SYSTEMATIC BEARING OF VARIATIONS

The data presented in the foregoing pages appear to demonstrate that certain variations occurring in the shell of *Teredo navalis* in San Francisco Bay have a definite and causal relation to corresponding ecological conditions. This inevitably suggests some discussion of the systematic treatment to be accorded such environmental forms.

The type of variate occurring in the upper bay has been described by Bartsch (1921) as *Teredo beachi*, n. sp., San Pablo Bay being designated as the type locality. The diagnostic characters which distinguish this form from the type of *Teredo navalis* are not definitely stated. But we note in the description mention of "a strong posterior auricle . . . umbones and a streak in the middle median portion . . . rose colored . . . dental ridges . . . very strongly denticulated . . . strong auricle . . . marked by rough lines of growth . . . center of the median portion is marked by a roughened area . . . auricle is marked by strong, curved lines of growth . . ." etc. The emphasis on the large auricle, color, strong denticulation, median roughened area, and prominent lines of growth, as well as the type locality given, identify this teredo as the environmental form which we have considered typical of the upper bay. The wide variation we have described in these characters obviously precludes such variants from specific rank. The question remains as to whether *beachi* should be retained as a subspecies, or included in the synonomy of *navalis*. In case of the former alternative, a subspecies would have likewise to be established for the form from the lower bay and perhaps, also, as further study might show, for each of several intermediate environmental forms at other localities, the Goat Island form being considered typical. It might even be necessary in some cases to establish subspecies for teredos from the top and the bottom of the same pile.

It will be recalled that the localities from which shells were taken for this study were chosen as representing the *extremes* of environment in which *Teredo* occurs in San Francisco Bay. And in attempting to establish the effect of environmental conditions in producing variation, we have naturally and legitimately emphasized the *differences* rather than the *similarities* observed among specimens from the localities in question. We would call attention to the fact that, while the extreme differences are rather marked, the mean differences among shells even from these specially selected localities are comparatively slight. In many, indeed, in most, cases it is impossible to take an isolated unmarked shell and declare from what locality it has come. By referring again to figure D it will be seen that shells having from 13 to 18 ridges per millimeter might come from any of the three localities considered, the curves overlapping to this extent. From figure F it is evident that the index of the auricle may range from 30 to 70 without indicating the locality from which a shell has come. A similar statement may be made regarding the other points of difference noted among these three environmental races. It is only in the case of the extreme variates that a locality diagnosis can be made on the basis of intrinsic characters of the shell.

Furthermore, as we depart from the extremes of environment, the differences mentioned appear to become more and more obscure, until they are entirely lost, the various races merging with each other at intermediate points. Sufficient material is not available adequately to illustrate this, but a few specimens are at hand from stations between Crockett and Goat Island which indicate at least the trend to such coalescence. From Oleum (see map) we find in 25 shells a variation of from 14 to 20 ridges per millimeter on the anterior median, and a range of from 28 to 67 in the index of the auricle, thus indicating, with due allowance for meager numbers, a slight departure in both these respects from the shells from Crockett, and a tendency more nearly to resemble shells from Goat Island. The shells from Oleum are also less pigmented and more translucent, and in general appearance give the impression of intermediateness between the brackish water and the salt water types. They differ from the Dumbarton shells in having rather more prominent lines of growth.

A solitary specimen from Pinole in our collection cannot be said to differ appreciably from the specimens from Oleum.

On the other hand, we have from off Point San Pablo and Point Richmond a few immature specimens which closely resemble *Teredo* of similar age from Goat Island.

These data, fragmentary as they are, throw much doubt on the advisability of attaching varietal names to any local groups. The free swimming larvae of *Teredo* are swept about by shifting currents to every portion of the bay, and with every breeding season a new distributional assortment must occur, so that any locality differences which appear in the mature animals must be the immediate result of environmental factors acting separately on each generation. The most conclusive proof of this has come in a very interesting way from what at first appeared to be a discrepancy in our data. It was observed that shells from the region of Carquinez Straits taken in 1920 differed appreciably from those taken in 1921 and subsequently, being distinctly more like the shells typical of the middle bay. For example, 40 shells collected at Crockett in 1920 averaged 15.8 ridges per millimeter on the anterior median portion, as compared with an average of 14.5 for shells collected there in 1921 and later. This proved very puzzling, until it was remembered that the winter of 1919–20 was a period of unusually scant rainfall and consequently lessened river discharge into the northern arm of the bay, resulting in a protracted period of rather high salinity in this region (Kofoid, 1921, p. 49). With the resumption of normal river discharge in the winter of 1920–21 the salinity was lowered. This seems to be the explanation of the differences found between shells collected here in 1920 and 1921 respectively.

The winter of 1919–20 was marked by probably the lowest river discharge since 1863–64 (Grunsky, 1921, p. 15); shells collected during this period were accordingly excluded in preparing the foregoing tables and graphs, as representing a departure from the normal.

They serve to illustrate, however, the degree to which variations in the shell of *Teredo* are immediately dependent on conditions of the environment.

The non-genetic nature of such variations is further indicated by the fact noted above (p. 308) that, under certain conditions, rather marked differences may occur between shells from near the upper and lower ends of the same pile.

Variation among the Mollusca in general is a conspicuous and well-known phenomenon, which cannot but impress itself upon every student of shells. A correlation of variation and environment has furthermore long been recognized and commented upon by a number of writers. As early as 1818 we find Burrow (p. 38) announcing that "varieties are formed, usually, by adventitious circumstances." Bateson (1889), Locard (1892), Clessin (1897), Davenport (1904), Bartsch (1906), Geyer (1909), Pilsbry (1912), and others have pointed out certain effects of the conditions of life on the characters of molluscan shells. Detailed studies of variation among certain groups with reference to environment have lately appeared, such as those by Adams (1915), Grier (1919 and 1920), Ball (1922), and Colton (1922). These writers are in general agreement that variations of a number of different types are definitely correlated with station, and hence are the result, at least in considerable measure, of the ecological conditions.

In the case of intra-specific variation which proceeds along sufficiently distinct and disjoined lines, and especially where the differences appear to be hereditary (Lang, 1906; Colton, 1922), there is doubtless ample reason for the establishment of appropriate subspecies. But variations such as those noted for *Teredo navalis* in San Francisco Bay, which apparently represent the immediate impress of the environment on the individual, afford an extremely precarious basis for the formation of new systematic groups. To recognize *beachi* or other local environmental forms of such indefinite claims is profitless to present investigators and can serve only to call upon our heads the anathemas of future workers in this field.

SUMMARY

1. A study of the growth of the shell of *Teredo navalis* in San Francisco Bay indicates that 8 or 9 cutting ridges are normally deposited during the first month of boring life, and 2 to 4 ridges per month thereafter. The rate of deposition of ridges tends to be lower in the less saline waters. Also, growth may be hindered or stopped as a result of crowding.

2. *Teredo navalis,* as occurring in San Francisco Bay, exhibits an extremely wide range of variation, involving practically every feature of the shell. The more salient of these variations—number of ridges per unit area of the shell, size of the auricle, prominence of the denticles, thickness of the periostracum, and amount of color present—have been found to be definitely correlated with factors of the environment, especially salinity and temperature.

3. The general trend of evidence is that these variations owe their origin immediately to environmental conditions, and are not inherited.

4. The local variates of *Teredo navalis* in San Francisco Bay, including *beachi* Bartsch, have not been found sufficiently well differentiated from each other to warrant their being classified as subspecies. Much less justification exists for assigning to any one of them a specific rank.

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Transmitted July 21, 1922.

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EXPLANATION OF PLATES

PLATE 13

Map of San Francisco Bay and tributaries.

Reproduced from Report of the San Francisco Bay Marine Piling Committee, 1921, by courtesy of the Committee. Numbers refer to stations discussed therein.

PLATE 14

Series of shells of *Teredo navalis* from Crockett, showing effect of environment on growth of ridges. Note on each shell the unusual width of the interspace separating the newest ridge (left) from previous ridges. × 9.

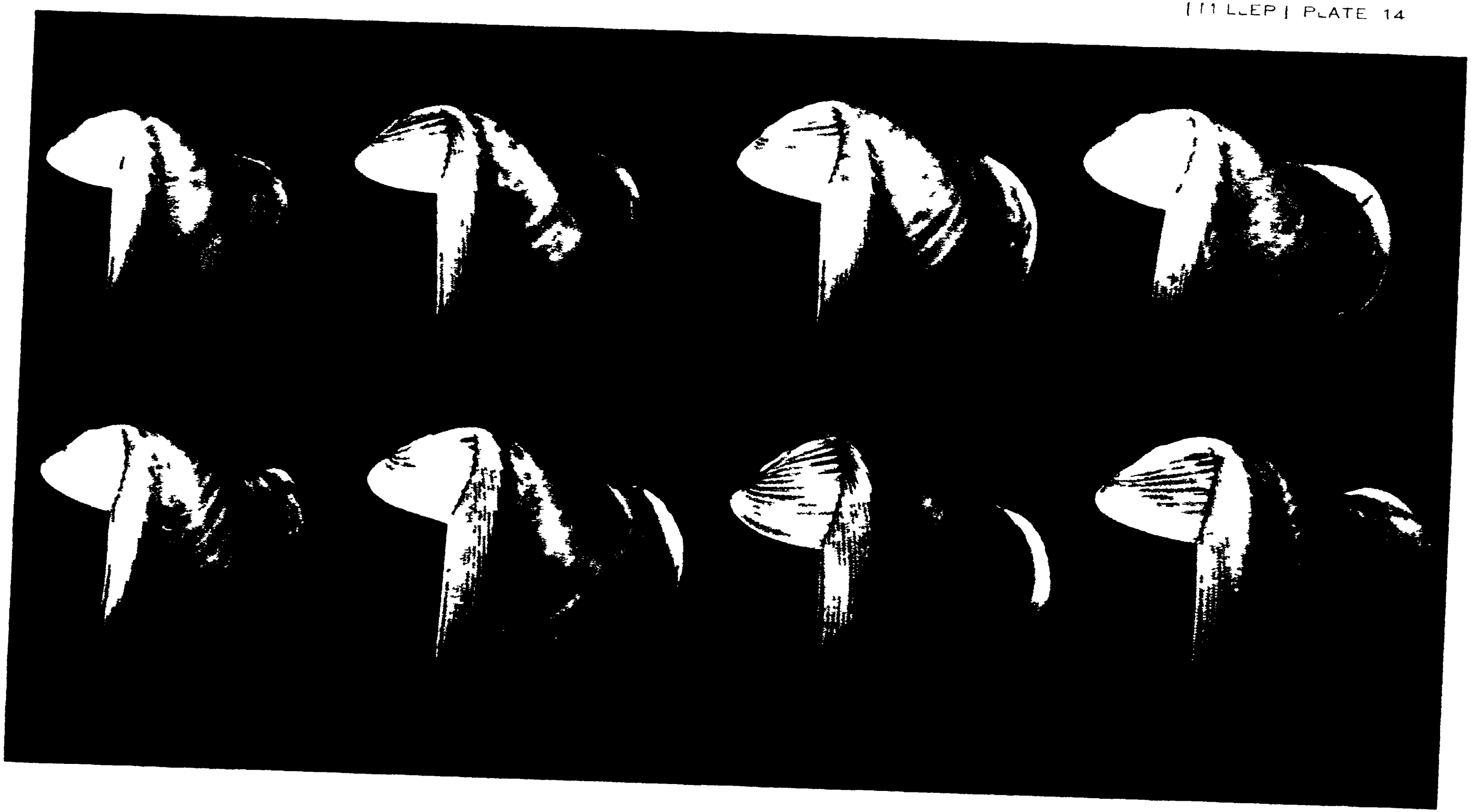


PLATE 15

Fig. 1. Comparison of series of shells from near the surface (left) and near the bottom (right) at Crockett. × 2½.

Fig. 2. Typical shell from near surface at Crockett. × 10.

Fig. 3. Typical shell from near bottom at Crockett. × 10.

Fig. 4. Series of shells from Crockett of progressively greater age from left to right, showing change in relative position of auricle through resorption of its dorsal edge with growth. × 4.

PLATE 17

Fig. 1. Comparison of extreme variates of each of the series figured in plate 5; Goat Island (left), Dumbarton (center), and Crockett (right). × 5.

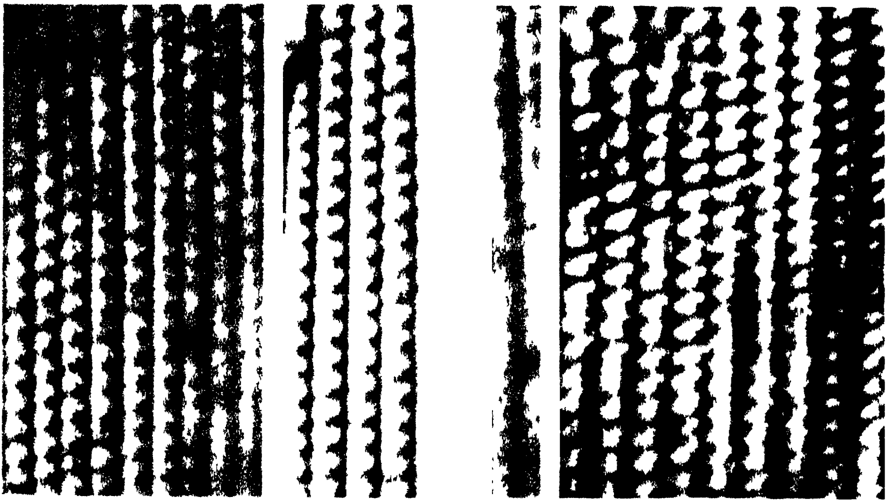
Fig. 2. Details of denticulation of a portion of the anterior median area of a shell from Goat Island. × 75.

Fig. 3. The same, from Dumbarton.

Fig. 4. The same, from Crockett.

Fig. 5. Shells from stagnant aquarium, discolored black by action of sulphur bacteria. × 4.

Fig. 6. Head of *Teredo*, with body and shell colored blue as a result of working in redwood in vicinity of an iron nail. × 4.



QUANTITATIVE STUDIES ON MARINE PHYTOPLANKTON AT LA JOLLA IN 1919

BY

WINFRED EMORY ALLEN

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(Contribution from the Scripps Institution for Biological Research of the University of California)

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INTRODUCTION

Beginning in 1901 and continuing from that time to the present under the active leadership of Dr. William E. Ritter, the San Diego Marine Biological Station, succeeded by the Scripps Institution for Biological Research of the University of California, has carried on varied and extensive investigation of oceanic phenomena. Under the pressure of explorational and other fundamental work little attention was given to the ecological study of phytoplankton until 1917, when the present writer was asked to develop the work along that line. The report covering preliminary operations of 1917 and 1918 has been published (Allen, 1921*a*) ; hence the present paper deals only with the work of 1919 after the beginning of standardized operations at the Scripps Institution.

Owing partly to shortage of equipment, no boat work was done by the Scripps Institution in 1919. As a consequence the collection of phytoplankton was limited to such work as could be done at the outer end of the pier, about 1000 feet from shore. Through the first eight months of the year daily hauls were made with a tow net. Efforts to make statistical studies of such material showed, however, that it was not very satisfactory for that purpose. Hence it became necessary to change the method of collecting which, after some experiment, was done on September 1, 1919.

The inadequacy of tow net catches was mainly due to the fact that at times in seasons of light production scarcely any phytoplankton was taken by a standard run of the net. Enumeration of such catches gave very little more information than was obtainable from casual inspection, i.e., that there was very light production of a very few forms. But tow net catches were also very unsatisfactory because it was impossible to say, even approximately, how much water had been traversed or filtered. Hauls were made over a measured distance but there was no way of knowing how strength and direction of currents, quantity of plankton, viscosity of the water, and abundance of sediment affected one catch as compared with another. For such reasons it was decided to preserve the tow net catches for qualitative reference and to confine quantitative studies to catches taken by the changed method. In this way the scope of this report is limited to the series of collections taken from the pier in the last four months of 1919.

LOCATION

The Scripps Institution lies in approximately 32° 50′ north latitude and 117° 15′ west longitude. It is about two miles distant from the village of La Jolla, near San Diego, California. Other marine localities in about the same latitude are Charleston, South Carolina, the Bermuda Islands, the Madeira Islands, Alexandria (in Egypt), and Shanghai, China. Very little study has been made of either marine or fresh-water plankton in or near this latitude, and there is practically no other series of collections of phytoplankton fairly comparable with the one now under discussion. Hence it is necessary when comparing with other work to bear in mind the markedly different geographic conditions. The water temperature at the pier varies from about 13° C. in January to about 23° C. in August. Water at the outer end of the pier is about 27 feet deep at high tide.

EQUIPMENT AND METHODS

I have in preceding papers (Allen. 1921 *b* and *c*) made brief statements concerning our standardized methods of collecting and handling material; those who desire more detailed information may obtain it by writing to The Director, Scripps Institution for Biological Research of the University of California, La Jolla, California.

THE MATERIAL

Marine phytoplankton in temperate regions consists mainly and essentially of diatoms and dinoflagellates. The material obtained at our pier is typical in this respect. It is all microscopic.

General Discussion

The regular series of catches at twelve hour intervals was begun at 8 A.M. on September 1, 1919. The new short net which was then put in use had been slightly shrunken and clogged by being used for making extra catches. In spite of this there was undoubtedly some loss of small forms through the meshes.

In most catches the living material consisted almost entirely of diatoms and dinoflagellates. There were times, however, when copepods, rotifers, and other very small animal forms were caught in considerable numbers. More rarely a few forms of various other kinds of microscopic plants were included.

According to a policy already determined after experience with phytoplankton from offshore waters, attention was confined to diatoms and dinoflagellates because their small size, large numbers, rapidity of growth, facility of multiplication, wide distribution, cosmopolitan character, and synthetic powers give them superior value as indicators of environmental conditions, mark them as the most favorable objects for quantitative study, and distinguish them as the most easily and continuously accessible of all marine organisms.

The distributional interrelationships of the two groups show many points of interest for which there are as yet no adequate grounds of discussion. This lack need not, however, invalidate tentative statements concerning them.

First, in making microscopic examination of the material I gained the impression that when diatoms were exceedingly abundant, dinoflagellates were rare, and vice versa. Hence I have earlier called attention to my belief in the possibility that the two groups are to some extent mutually exclusive of each other. It is still an open question whether this amounts to anything more than the commonly observed fact that excessive abundance of one group of organisms tends to reduce or exclude certain other groups. In fact, it is quite possible that many cases of apparent reduction of one under dominance of the other were merely apparent because dilutions for counting the abundant form rendered the other inconspicuous.

Both groups show rhythms and pulses of production which are more or less evident in each month of the year although, of course, the species concerned in the pulses vary according to season. It is rather difficult to define a pulse, but for present purposes I am arbitrarily assigning the term to a marked increase in numbers which extends over a period of three or more days before decreasing to or near the numbers found at its beginning. Of pulses in this arbitrary sense there were five for diatoms and four for dinoflagellates in the last four months of 1919 at our pier. The diatom pulses were unevenly distributed, two occurring in September, none in October, one in November, and two in December. The dinoflagellate pulses had similar distribution by months except that there was only one in

December. A diatom pulse at the middle of September was almost precisely coincident with a dinoflagellate pulse and there was partial coincidence of pulses of the two groups just after the middle of December. The fact that out of four chances for coincidence there were two close approximations to coincidence of pulses gives strong indication that both groups of organisms are often favored by the same stimuli to production, hence the idea that they may be mutually exclusive may seem unwarranted.

But an examination of the evidence from swarms shows other possibilities. A swarm may be arbitrarily defined for present purposes as a close aggregation of relatively large or even vast numbers of organisms of a certain group. Although what I have called a pulse may be (at least in some cases) due to the slow drift passing of an enormous swarm which occupies an area of several miles, I think we may confine present discussion to evidence of small swarms. This evidence consists merely in a conspicuous large catch found between much smaller catches, mostly less than one-third as large. Swarms identified in this way were, as might be generally expected, much more numerous than pulses in spite of the fact that nearness to shore made it probable that many swarms would be dispersed by the great disturbance in shallow waters. In the four months there were fourteen swarms of diatoms and fifteen swarms of dinoflagellates. Out of the fourteen chances for coincidence of swarms of the two groups only four actually occurred, a fact which might lead one to think the two groups somewhat deterrent to each other.

Not only does the evidence of pulses and swarms raise some interesting questions as to the interrelationship of the two great groups of synthetic organisms; it also has direct bearing on the perennial postulate that marine organisms are uniformly distributed through considerable areas of marine waters. The occurrence of pulses and swarms such as those just mentioned certainly tends strongly to contradict this assumption.

Further evidence tending to such contradiction appears in what, for lack of a better term, I may call skips. In the present connection a skip means a single strongly marked reduction in numbers in a way similar to that in which a strong increase is considered to indicate a swarm. In the four months, diatoms showed ten skips and dinoflagellates five, no two of which coincided. Surely a marked lack of organisms in a catch as compared with a catch twelve hours before and another twelve hours after gives good reason to suspect that differences in distribution occur without appreciable difference in immediate environmental conditions.

Another point of interest concerns the relative amounts of morning and evening catches. In the following table, record is given merely of the number of times in the month that morning or evening catches were the larger. The results shown by this table have been checked up by a table showing the number of times in each month that a morning catch was higher or lower than both the evening catch preceding it and the evening catch following it, and by a similar table for evening catches. The substantial agreement in the three tables makes it fair to state that this table correctly indicates distribution in morning and evening catches.

MORNING AND EVENING MAXIMA *

Diatoms	*Dinoflagellates*
September	September
Maxima at 8 A.M. 14 (5 catches near mean)	Maxima at 8 A.M. 12 (3 catches near mean)
Maxima at 8 P.M. 16 (4 catches near mean)	Maxima at 8 P.M 18 (2 catches near mean)
October	October
Maxima at 8 A.M. 23	Maxima at 8 A.M. 12 (1 catch near mean)
Maxima at 8 P.M. 8 (2 catches near mean)	Maxima at 8 P.M 19 (2 catches near mean)
November	November
Maxima at 8 A.M. 24 (3 catches near mean)	Maxima at 8 A.M. 20 (3 catches near mean)
Maxima at 8 P.M. 6	Maxima at 8 P.M. 10 (3 catches near mean)
December	December
Maxima at 8 A.M. 13	Maxima at 8 A.M. 15 (5 catches near mean)
Maxima at 8 P.M. 18 (1 catch near mean)	Maxima at 8 P.M. 16 (1 catch near mean)

It is very plain that no conclusions can be drawn from evidence so limited and contradictory, but it may be permissible to make suggestions. It seems strongly probable that there is a tendency to a diurnal rhythm in productivity, a rhythm which might be expected from what we know concerning fresh-water plants and land plants. If, according to such expectation, the phytoplankton is mainly active in photosynthesis by day and mainly active in growth and reproduction by night, we should get the results shown for diatoms in October and November, i.e., larger numbers in the morning catches.

Considering the multiplicity of factors involved, the large number of component species in the samples taken, and the variable speed and direction of water currents traversing the fixed point of collection, it is rather more surprising to find such a strong indication of rhythm than it is to find the neutral or contradictory evidence of the other two months. Even the reverse showing of the dinoflagellates is suggestive of diurnal rhythm in that group, although it is characteristically more erratic in distribution than the diatoms. At any rate the records suggest possibilities which are very interesting and which certainly open up a wide field for investigation.

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* I.e., one catch larger than the other. In a few cases the differences in numbers were very slight, but usually there was considerable difference at the two times of day.

In closing this general discussion of the material, I would remark that in the study of these two groups it was soon found that relatively few species showed marked prominence at any time, and that very few species had such prominence either frequently or continuously. Fortunately, most of these species can be satisfactorily identified under ordinary conditions of study.

A table giving the total numbers of phytoplankton cells per liter in all catches throughout the four months is given on pages 346–347.

Detailed Discussion

DIATOMS

Throughout most of the year and in most localities diatoms are both numerically and volumetrically the most prominent photosynthetic organisms in the open sea. The records for this four month period show characteristic conditions in this respect, November being the only month in which dinoflagellates appeared in superior numbers for the month as a whole.

Except for four catches in early September diatoms were always found to be present, though often in very small numbers. Since it is probable that larger samples would have revealed some in the four catches in which they were found lacking, it may be safely assumed that some diatoms might have been found at any time in the whole period.

Distribution of diatoms throughout the period was quite irregular, the most remarkable feature being very high productivity in the last three weeks of September following a season of extremely scant production and preceding a time of very light production. The accompanying graph (fig. 1) giving production in terms of averages of five day periods shows this condition with astonishing clearness. The areas filled in solid black indicate the relative size of average numbers found in each five day period.

In a general way the distribution agrees with that reported for the last four months of the year in other localities, both marine and fresh water. It therefore seems certain that, considering the group as a whole, we have in this case a normal seasonal sequence. It is not so certain that the production of species or even genera involved follows any established course at least so far as has yet been detected or predicted.

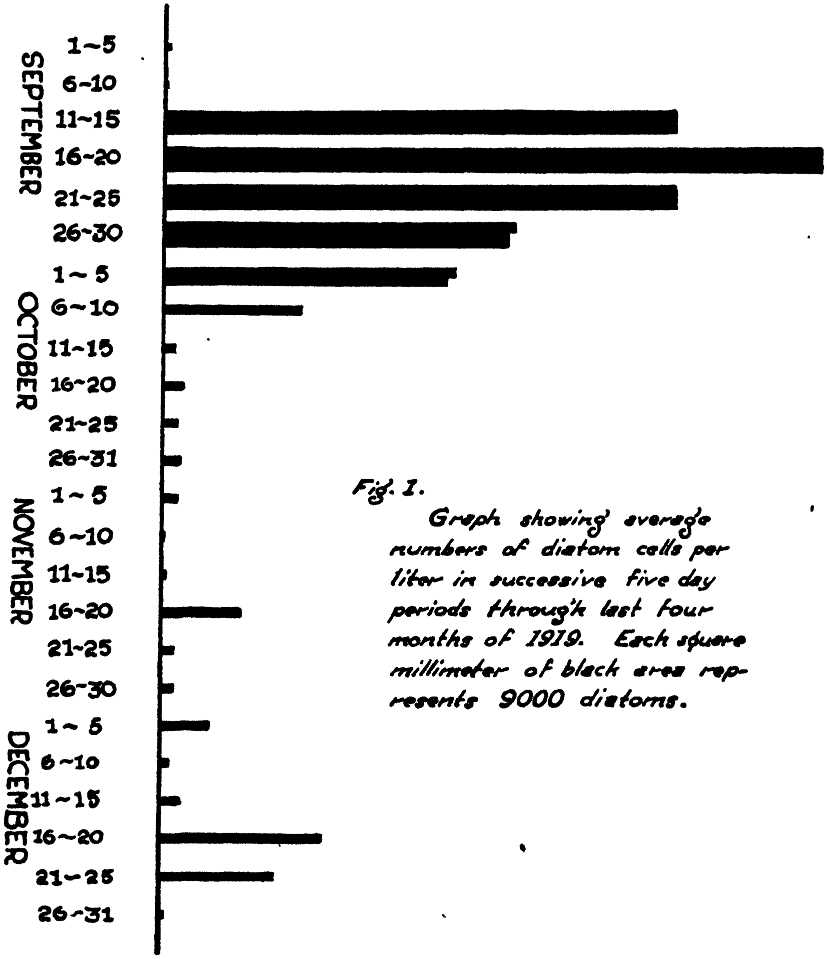

Fig. 1.
Graph showing average numbers of diatom cells per liter in successive five day periods through last four months of 1919. Each square millimeter of black area represents 9000 diatoms.

In connection with the high productivity so suddenly appearing in September, I was very much interested to note that for two or three days previously there had been rather strong and constant currents from the north. Also, large numbers of mackerel came to the region of our pier in the latter part of August and left as high production of diatoms began. Whether these facts were simply coincidences or whether they had significant relationship to increased diatom production I do not have means of knowing.

Although all other production was very inconspicuous as compared with the September maximum there was a pulse covering two days, November 17 and 18, at one time, and another covering six days, December 17–23, at another time. Since there was little current recorded at the November pulse its abrupt increase of some fifteen-fold may simply indicate the presence of a swarm stranded in quiet waters. While the December pulse at its highest showed about the same increase in production, its development was much less abrupt and so was its disappearance. In this case also the currents recorded were weak and the difference in development as compared with the November pulse might be considered due to relatively rapid production induced by some favorable local factor or favorable change in the factorial complex.

Forty-six forms of diatoms are listed as occurring within the four months in sufficient numbers to deserve separate mention. Of these only twelve had specific characters sufficiently marked to make identification easy. Fourteen could sometimes be satisfactorily identified and usually approximated, i.e., confusion was limited to only one or two other forms. Of the other twenty, some were always doubtful and others were simply grouped under the genus name because of small numbers or great uncertainty of identification.

The *Chaetoceras* genus offers most constant difficulties of this sort on account of its constant representation and on account of the fact that many species characters are based on conditions at sporulation or on terminal setae which may be missing. It is also true that many *Chaetoceras* chains are more or less twisted in form and that they lodge in all sorts of positions in the counting cell. Identification might be possible with unlimited time and effort, but it is not practicable to insure accuracy under counting conditions. Some *Chaetoceras* species could not be identified because of small size, as was also true of diatoms in other genera. In the main, however, the more important forms numerically in this series of catches were at least approximately identified as to species and almost all were correctly placed as to genus.

By selecting in each month the five species which showed the highest averages it is possible to get a good general idea of the character of the main diatom population throughout the four month period. Eleven forms are recorded in the highest five in one or more months. *Chaetoceras* sp. appears in this list in all four months. *Chaetoceras curvisetum* Cleve in three months, *Chaetoceras debile*

Cleve in three months, *Dactyliosolen tenuis* Cleve and *Nitzschia seriata* Cleve in two months, and the following in one month: *Chaetoceras decipiens* Cleve, *Chaetoceras didymum* Ehr., *Leptocylindrus danicus* Schütt, *Rhizosolenia alata* Btw., *Skeletonema costatum* Grev., and *Nitzschia pungens* Grun.

Certain forms which were originally recorded while counting have been omitted from the tables for one or more months because of small numbers or questionable identification. Their numbers have, however, been included in the total diatoms. These include *Amphiprora alata* Kütz., *Asterionella japonica* Cl., *Bacillaria paradoxa* Gmel., *Bacteriastrum varians* Laud., *Biddulphia longicruris* Grev., *Cerataulina bergonii* Perag., *Chaetoceras ralfsii* Cl., *Climacosphenia moniligera* Ehr., *Corethron criophilum* Castr., *Ditylium* sp., *Eucampia zoodiacus* Ehr., *Grammatophora marina* Lyngb., *Hemiaulus heibergii* Cl., *Lauderia borealis* Gran, *Leptocylindrus danicus* Cl., *Licmophora lyngbyei* Kütz., *Lithodesmium undulatum* Ehr., *Melosira* sp., *Nitzschia closterium* W. Sm., *Nitzschia* sp., *Rhizosolenia faeroensis* Ost., *Rhizosolenia hebetata* Bail., *Rhizosolenia obtusa* Hensen, *Rhizosolenia robusta* Norm., *Rhizosolenia setigera* Btw., *Rhizosolenia styliformis* Btw., *Stephanopyxis palmeriana* Grun., *Surirella* sp., *Thalassiosira baltica* Grun., *Thalassiothrix longissima* Cl.-Gr., and *Thalassiothrix nitzschiodes* Grun.

For similar reasons a number of species originally listed have been grouped together in their genera or under a loosely applied species name. This is especially true of some forms in *Chaetoceras, Biddulphia, Coscinodiscus,* and *Rhizosolenia* genera.

Gran's paper (1908) has been most helpful in identifications.

SPECIES OF DIATOMS

For economy of space I shall confine discussion mainly to the eleven species represented in the lists of the five species most abundant in one or more months. These are distributed unequally among six genera listed in alphabetical order as follows:

Chaetoceras.—This genus had relatively high numerical representation in every month. It was responsible for the high records of production in September, when several species far outnumbered representatives of any other genus. No large *Chaetoceras* forms were present and some were very small. Even so, the genus appears to be more productive than other diatom genera in volume as well as in numbers. Roughly, it may be said to be the most important genus of planktonic diatoms.

Chaetoceras curvisetum Cl.—Frequently confused in our records with *Ch. debile* Cl. I have not found any satisfactory way to distinguish the two forms while counting. When possible, segregation has been made according to Gran's (1908) suggestion that interspaces between the cells are biconvex in *Ch. curvisetum* and rectangular in *Ch. debile.* Sometimes one and sometimes the other is very abundant and both are very commonly found in our waters. Segregation is attempted merely because the records, though imperfect, may sometime show some value.

In September the species reached a maximum of 276,000 per liter at 8 P.M. on the 14th. It was missing entirely from many catches before the 11th but showed a very strong and even development of production after that date until the maximum was passed, when the numbers gradually decreased. Average production for the month was 32,089 per liter. These numbers refer to cells. On account of curvature of the chain of cells exact enumeration was often impossible but the approximation is usually close. This species was frequently missing in catches in the other three months and it is quite evident that its abundance in September was due to a favorable combination of environmental factors.

Chaetoceras debile Cl. has a record of distribution and of appearance markedly similar to that of *Ch. curvisetum* Cl., and there is little to say about it at present. Maximum production of 81,000 per liter was reached at 8 P.M. on September 17.

Chaetoceras decipiens Cl. was not always clearly identified. Shape of cells and of interspaces varied greatly and the typical form was rarely seen. Basal fusion of the setae was the characteristic relied upon for recognition and even it was sometimes questionable. Numerous gradations between the typical form and some which were otherwise scarcely recognizable were often found on the same slide. Representation in September as well as in other months was rather irregular, the maximum, 27,200, being reached on September 26 at 8 P.M. in a poorly developed three day pulse. *Ch. decipiens* was entirely missing through two-thirds of October and a large part of November. When present in the last three months of the year representation was light.

Chaetoceras didymum Ehr. was never very prominent in any catches, although its identity was probably often overlooked. Its characteristics are somewhat variable, especially as to general appearance of the chain and of the setae. It was probably confused sometimes with *Ch. constrictum* Gran and some other forms. Its maximum was reached on September 16 at 8 A.M. in a catch numbering 14,800, the average for the month being 1674. It is not recorded after the middle of October.

Chaetoceras sp. is a catchall for a large number of species difficult to identify, or rare. In the four months under consideration its main components were small forms with poorly marked characters, of which *Ch. affine* Laud. was probably most prominent. Numerically and probably volumetrically this assemblage was distinctly the most important of the diatoms in September, October, and December. The maximum, 339,376, was recorded for September 24, 8 P.M., and there was an average for that month of 90,069 per liter. High production of this group began about September 11 and lasted almost a month. Its numbers in the catches then became very small until the latter part of November. While not very abundant, considerable numbers were found through most of December.

Dactyliosolen was represented apparently by only one species, *D. tenuis* Cl., and identification in many cases was not very certain. It was fairly well represented in October and November, but very slightly in the other two months. Maximum, 5700 per liter, October 21, 8 A.M., average in October, 1464.

Leptocylindrus also showed only one species, *Leptocylindrus danicus* Schütt. This form attained considerable prominence in late September and early October, but was almost or quite absent at other times. Maximum production, 17,600, was reached on October 6 at 8 A.M. and the average in October was 2187. This form does not appear to be of great importance in our region.

The genus *Nitzschia* was probably represented by several species but only two attained much numerical importance. *N. seriata* Cl. and *N. pungens* Grun. Their distribution as recorded was essentially similar and there were very many cases in which it was uncertain whether the specimen was rightly called *N. pungens* or whether it was merely a small specimen of *N. seriata*. Such cases, together with the similarity in distribution, lead one to think that perhaps the two forms may both be properly included under *N. seriata*. There is, however, some advantage in keeping the records separate, since a marked and fairly consistent deviation within the species may help to show the influence of certain environmental factors, such as temperature in relation to growth, shape, etc.

Nitzschia seriata Cl. is a very prominent diatom in this region. It may be found at any time of year though surface catches indicate that it is typically a winter or spring form. It has been found in large numbers in July and August in vertical tow net catches taken from two hundred meters to surface near Santa Cruz Island and in one or two other localities. This fact leads to the supposition that this as well as other forms of the phytoplankton may flourish at the surface in one season and at a lower level in another season. The largest catch of *N. seriata* in the four months was on December 22 at 8 P.M. The number was 5900 per liter and the average for the month was 830. The maximum occurred in a well developed pulse which began on December 15 and ran ten days.

As already stated, *N. pungens* is often not readily distinguishable from *N. seriata*. Its occurrence in December was coincident with the latter in a pulse that ran the same course. The maximum was reached at 8 A.M. on December 20 in a catch of 7700 per liter and the average for the month was 831.

The genus *Skeletonema* is represented in our catches by only one species, *Skeletonema costatum* Grev. Its numbers were few in September and it was missing in October. Occurrence in November was very irregular, although it was conspicuous in a few catches just after the middle of the month. In December it appeared more regularly in the catches and reached a maximum of 4160 per liter on the 19th at 8 A.M. The average for December catches was 919 per liter. *S. costatum* is frequently found in our region and is probably an important general constituent of our phytoplankton.

No other genera of diatoms reached much importance in the four months and there does not seem to be anything in records of their occurrence which is not in essential agreement with those of the genera just discussed. Evidently any peculiar significance which they may have can only be determined by careful statistical analysis.

One point, however, is clearly shown by detailed studies, i.e., that when there is a pulse of the highly productive forms there is also a pulse or marked increase in numbers of those forms of lower production and there is also an increase in the number of species and of genera represented. This also seems to be true to a lesser extent of swarms. Such facts naturally lead to the assumption that in a general way ecological conditions in the sea favorable to high production of diatoms affect a large number of forms in the same way.

DINOFLAGELLATES

Although some dinoflagellates are nearly always present in plankton catches taken in the San Diego region, they are often very few, and they are rarely so numerous as diatoms. This deficiency in numbers is compensated to some extent by the fact that many prominent dinoflagellates are larger than any planktonic diatom cells and also by the fact that living substance constitutes a larger part of the cell body in dinoflagellates than it does in diatoms. But even when we accept the statement made by Johnstone (1908, p. 192) that one peridinian contains as much dry matter as twelve diatoms, it still appears that dinoflagellate production over long periods of time is distinctly less than diatom production, volumetrically as well as numerically. As to the four months now under discussion, however, we may note that although dinoflagellates were found in distinctly greater numbers than diatoms only in November, in October and December their numbers were one-eighth and one-fourth as great, respectively, as those of diatoms, which according to the ratio mentioned by Johnstone would indicate that they were volumetrically more important than diatoms in three months out of the four.

At least a few dinoflagellates were present in every catch made at this time. Their distribution was somewhat irregular though not so markedly so as that of the diatoms. The extremes were not so great and the representation was more constant in spite of the generally smaller numbers. This, however, was offset to some extent by the more frequent and sudden changes in numbers (fig. 2). In figure 2 the areas filled in solid black indicate the relative average numbers found in each five day period (including ten catches), except in October and December where the last period consists of six days with twelve catches.

The general features of distribution in the four months seem to be essentially similar to those of distribution reported for other localities. As in the case of the large diatom pulse in September, the largest dinoflagellate pulse, which came in November, was preceded for a day or two by strong currents of water from the north and was also accompanied by moderate currents from that direction. While it is not probable that these currents flowed continuously in the one direction, it is probable that the main shift of the water mass was that way. A successful recording apparatus for water currents was put in operation at one time by our hydrographer, Dr. G. F. McEwen, but no means was found to protect it from rough seas and it was only in operation for a short time. For that reason records of currents are made from observations at times of taking catches.

Thirty-seven forms of dinoflagellates are listed as occurring within the four months in sufficient numbers to deserve separate mention.

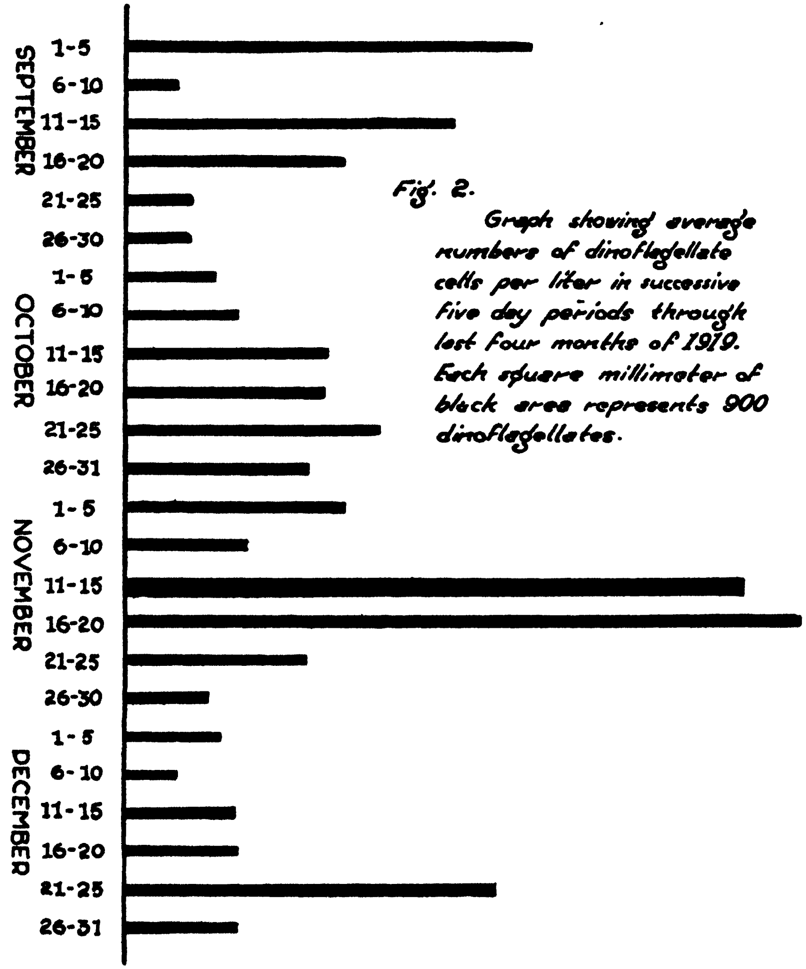

Fig. 2. Graph showing average numbers of dinoflagellate cells per liter in successive five day periods through last four months of 1919. Each square millimeter of black area represents 900 dinoflagellates.

Of these only eight had specific characters sufficiently well marked to make identification easy. Twelve forms could be sometimes satisfactorily identified and usually approximated, i.e., confusion was limited to only one or two other forms. Of the other twenty-five, some were always doubtful and a few were simply grouped under the genus name because of small numbers or uncertainty of identification. There was more or less difficulty in identifying species in all genera.

There was not often any difficulty in identifying the genus to which a specimen belonged. Identification was usually fairly satisfactory in case of the forms which appeared to be numerically important. Certain errors in identification of species on account of the position of the specimen in the counting cell were no doubt frequent.

As in the case of diatoms it seems possible to get a fair general idea of the dinoflagellate population in a month by selecting the five showing higher numerical averages for the month. In a list thus selected four species appear throughout the four months, *Ceratium furca* (Ehr.). *Dinophysis homunculus* Stein, *Gonyaulax polyedra* Stein, and *Prorocentrum micans* Ehr.; all are, in most cases, easily identified. Of the two other species listed in the first five, *Ceratium fusus* (Ehr.) appears in three months and *Peridinium divergens* Ehr. in one.

Certain forms which were originally recorded while counting have been omitted from our final tables for one or more months because of small numbers or questionable identification. Their numbers have, however, been included in the total dinoflagellates. The names are *Ceratium arcticum* (Ehr.). *Ceratium breve* (Ost. & Sch.), *Ceratium gallicum* Kof., *Ceratium macroceros* (Ehr.), *Ceratium pennatum* Kof., *Ceratium pentagonum* Gour., *Ceratium tripos* (O. F. M.), *Dinophysis acuta* Ehr., *Dinophysis hastata* Stein, *Dinophysis ovata* Clap. & Lachm., *Gymnodinium* sp., *Noctiluca miliaris* Surir., *Oxytoxum scolopax* Stein, *Phalacroma rudgei* Murr. & Whitt., *Phalacroma rapa* Stein, *Peridinium grani* Ostf., *Peridinium pellucidum* (Bergh), and *Pyrocystis lunula* Schütt.

A number of species originally listed have been grouped together in their genera or under a loosely applied species name for similar reasons. This is especially true of some forms in *Ceratium, Dinophysis, Gonyaulax,* and *Peridinium.*

Paulsen's paper (1908) has been most useful in identifications.

For economy of space, detailed discussion of species of dinoflagellates is omitted from this paper. Kofoid's careful studies (Kofoid, 1907 *a* and *b* and 1911) have given much more knowledge of the members of this group than is the case with diatoms.

CONCLUSION

Since the work of 1920 and 1921 has been a direct extension and expansion of the work in 1919 it is scarcely desirable or appropriate to attempt to state very much in the way of general conclusions in this immediate connection. Such a statement can be more satisfactorily attempted after study of the records for one or more years.

Meanwhile, however, one or two points may be noted to advantage:

First, the measured water method seems to be by far the best for a *standard* method and the surface level the best for a *standard* level of collecting. At the time of this writing, May 26, 1921, we have given a continuous trial to this plan of procedure over a period of twenty-one months at our pier and fifteen months at another. In addition we have used it on various boats and now have it in operation at three other piers. From such experience we are convinced that it is the only method affording an adequate basis for expansive quantitative work on the phytoplankton as distinguished from the elementary, superficial work permitted by any tow or haul net method.

Second, it appears probable that water currents have very pronounced influence on phytoplankton production.

Third, when conditions for production are highly favorable in our area, there is evident response by large numbers of phytoplankton organisms frequently of both dinoflagellates and diatoms.

Fourth, conditions of occurrence suggest the probability that certain common forms of wide distribution, such as *Nitzschia seriata* Cl. and *Prorocentrum micans* Ehr., may serve well as indicators of certain general conditions of the ecologic complex while some less abundant forms, such as *Asterionella japonica* Cl. and *Dinophysis homunculus* Stein, may prove to be excellent indicators of more specific conditions in the ecologic complex.

Lastly, it is evident that the problems of the ecologic complex of the sea are fascinating as well as intricate and baffling; e.g., was the big diatom pulse in September due merely to the transfer into our area of a seed bed of diatoms which had developed farther north? Or was it due to removal of predatory copepods by the small fish which the mackerel chased in? Or was it due to the high increase in carbon dioxide and nitrogenous materials resulting from the presence and activity of unusual quantities of fish? Or was it due to a combination of all these, with a thousand other influences, the resultant of all of which was good?

TOTALS OF PHYTOPLANKTON. NUMBER CELLS PER LITER

Pier series. 8 A.M. and 8 P.M. September to December, inc., 1919
Scripps Institution for Biological Research, University of California

Date	Hour	September	October	November	December
1.	8 A.M.	5,522	214,480	4,036	5,616
	8 P.M.	1,148	154,352	6,960	5,644
2.	8 A.M.	6,614	74,624	5,092	6,236
	8 P.M.	3,288	59,872	3,344	14,416
3.	8 A.M.	4,628	48,624	10,344	11,520
	8 P.M.	6,216	56,936	4,160	18,192
4.	8 A.M.	16,444	45,480	8,216	9,504
	8 P.M.	6,096	32,712	3,012	800
5.	8 A.M.	6,904	27,726	2,548	1,824
	8 P.M.	1,804	51,504	1,224	2,076
6.	8 A.M.	480	33,200	1,796	2,364
	8 P.M.	276	48,008	1,264	3,488
7.	8 A.M.	172	26,800	1,224	1,492
	8 P.M.	392	28,904	952	1,732
8.	8 A.M.	360	26,640	1,148	868
	8 P.M.	1,048	10,608	784	1,856
9.	8 A.M.	864	7,288	1,868	1,184
	8 P.M.	1,718	5,944	2,640	1,496
10.	8 A.M.	1,402	5,280	3,236	2,008
	8 P.M.	1,348	3,040	4,080	772
11.	8 A.M.	4,380	6,160	7,860	1,760
	8 P.M.	15,608	8,084	16,856	1,720
12.	8 A.M.	105,328	6,928	11,952	2,304
	8 P.M.	58,392	6,424	6,484	936
13.	8 A.M.	135,904	2,184	37,816	1,348
	8 P.M.	169,296	1,868	29,736	780
14.	8 A.M.	279,376	1,532	27,728	2,816
	8 P.M.	367,232	2,956	9,692	6,808
15.	8 A.M.	450,912	1,872	9,428	13,312
	8 P.M.	471,104	3,080	8,680	7,668
16.	8 A.M.	279,160	2,708	8,620	6,228
	8 P.M.	348,640	4,864	5,040	8,216
17.	8 A.M.	384,960	5,180	33,372	11,484
	8 P.M.	485,240	1,872	43,376	16,684
18.	8 A.M.	333,120	7,908	56,116	18,620
	8 P.M.	183,440	7,000	11,744	23,904
19.	8 A.M.	129,920	5,340	17,164	23,460
	8 P.M.	200,280	6,232	3,592	34,180
20.	8 A.M.	103,584	8,468	4,712	45,572
	8 P.M.	161,280	3,192	7,756	36,512
21.	8 A.M.	153,888	8,852	8,360	25,976
	8 P.M.	96,960	1,796	2,700	34,836
22.	8 A.M.	174,832	6,616	2,450	24,944
	8 P.M.	196,592	2,088	4,160	32,304
23.	8 A.M.	104,528	15,496	4,424	17,172
	8 P.M.	260,464	2,244	2,216	14,284

Totals of Phytoplankton. Number Cells per Liter—(*Continued*)

Date	Hour	September	October	November	December
24.	8 A.M.	185,312	6,140	6,304	14,412
	8 P.M.	340,784	2,136	6,292	16,824
25.	8 A.M.	270,448	3,380	1,344	5,764
	8 P.M.	233,888	4,140	1,980	10,352
26.	8 A.M.	132,928	5,340	1,876	3,088
	8 P.M.	130,624	3,228	2,952	3,464
27.	8 A.M.	265,024	5,828	1,528	3,680
	8 P.M.	160,400	3,232	2,208	1,520
28.	8 A.M.	115,904	3,396	2,184	3,136
	8 P.M.	49,664	3,808	1,312	3,016
29.	8 A.M.	65,408	10,504	2,984	824
	8 P.M.	89,792	5,192	1,976	1,624
30.	8 A.M.	254,224	4,624	6,528	1,160
	8 P.M.	103,904	3,128	3,432	744
31.	8 A.M.		3,720		744
	8 P.M.		4,208		568

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ON THE EFFECT OF LOW SALINITY ON TEREDO NAVALIS

BY

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INTRODUCTION

Teredo navalis inhabits a very wide range of salinities. In Holland (Vrolik, *et al.*, 1860–1864; Van Oordt, *et al.*, 1865) these borers were found at points practically exposed to the open sea at Vlissingen on the North Sea at the mouth of the Schelde River, where the salinity remains near 30 parts per 1000, and at Harlingen on the Zuider Zee, where the salinity ranges between 20 and 30 parts per 1000. They also inhabit the brackish waters of the Ij near Amsterdam, where the salinity falls as low as 6 parts per 1000. In San Francisco Bay (Kofoid, 1921–1922) *Teredo navalis* was established by the autumn of 1920 not only in the more saline waters at Goat Island and along the San Francisco waterfront, but also in the brackish waters of Carquinez Straits and the Delta of the San Joaquin River.

Barrows (1917) described the initial infection of the Mare Island dikes and other structures at the head of San Pablo Bay in 1912–1913 by a species of *Teredo* identified at that time by Bartsch as *T. diegensis,* which was undoubtedly *T. navalis.* Since that time *Teredo* has spread rapidly into the fresher waters of Carquinez Straits (Kofoid, 1921) and upstream as far as Antioch on the San Joaquin River, twenty miles from San Pablo Bay and fifty from the Golden Gate.

In the region of Carquinez Straits and upstream from this point, the salinity of the water is subject to great changes, varying with tides and with seasonal fluctuations of the discharge of the San Joaquin and Sacramento rivers. The seasonal variation of the salinity is of great importance with regard to the distribution of the borers, as at some points the salinity is high enough for their survival only during certain months. Thus, although the borers were able to establish themselves above Carquinez Straits during the summer and fall months when the rivers were low and the salinity comparatively high, they were nevertheless killed off there during the winter and spring months of extreme run-off and low salinity. The critical point seems to be at Carquinez Straits. There, in some years, the salinity is lowered sufficiently to kill off at least a large proportion of the teredos, while, in other years, it remains high enough to allow nearly a total survival.

The chief aim of the present investigation has been to determine the lethal, or death producing, salinity for this species of borer and the period of survival in various salinities.

This work has been carried on as a phase of the investigations of the San Francisco Bay Marine Piling Committee, the particular investigation being made possible by the kindness of the California and Hawaiian Sugar Refining Corporation, who have provided the experiment station and laboratory facilities. I wish here to acknowledge the kind assistance of Mr. A. A. Brown, Construction Engineer for the above corporation, and the invaluable advice and supervision of Professor Charles Atwood Kofoid of the University of California.

METHODS AND EQUIPMENT

The study of various factors affecting *Teredo navalis* was carried on at the temporary experiment station on the dock of the California and Hawaiian Sugar Refinery at Crockett, California. This station included ninety individual aquaria, which were constructed from wooden buckets of about two and one-half gallon capacity, each equipped with a bar and wedge for holding the specimen in place (fig. 1). The specimens used were sectors cut from sections of teredo-infected piles; they were eight inches in length and three to four inches in width across the outer or curved surface of the pile. A supply of sea water was provided by pumping water from the straits into two 10,000 gallon wooden storage tanks. Fresh water was obtained from the supply of the California and Hawaiian Sugar Refinery. This supply was obtained from surface water at Carquinez Straits and the Sacramento River at the time these experiments were conducted, and was subjected to treatment with aluminum sulfate and to mechanical filtration prior to our use of it. A maximum of 10 parts per 100,000 of sodium chloride is allowed in this water before treatment. The water of various salinities used in the following experiments was obtained by diluting the stored water from the straits with fresh water from the supply.

The measure of salinities used is based on determination of chlorine by titration with silver nitrate, the total salinity in parts per 1000 being obtained by reference to the international hydrographic tables (Knudsen, 1901). The formula on which these tables are based is $S = 1.8050\ Cl + 0.030$. This method of determining salinity is the one used by the San Francisco Bay Marine Piling Committee (Kofoid,

1920) in investigations on teredos and other marine borers. It gives approximately the proportion of ocean water in straits water, but includes also the saline content of the stream and seepage water. Such a standard may allow a small error when used as a measure of actual physiological properties of sea water, particularly in Carquinez Straits where great amounts of river water are present during several months of the year and various sources of industrial pollution are probable. It serves as a convenient standard, however, and the actual error is probably not greater than other experimental errors. All references to salinities are based on this method of determination.

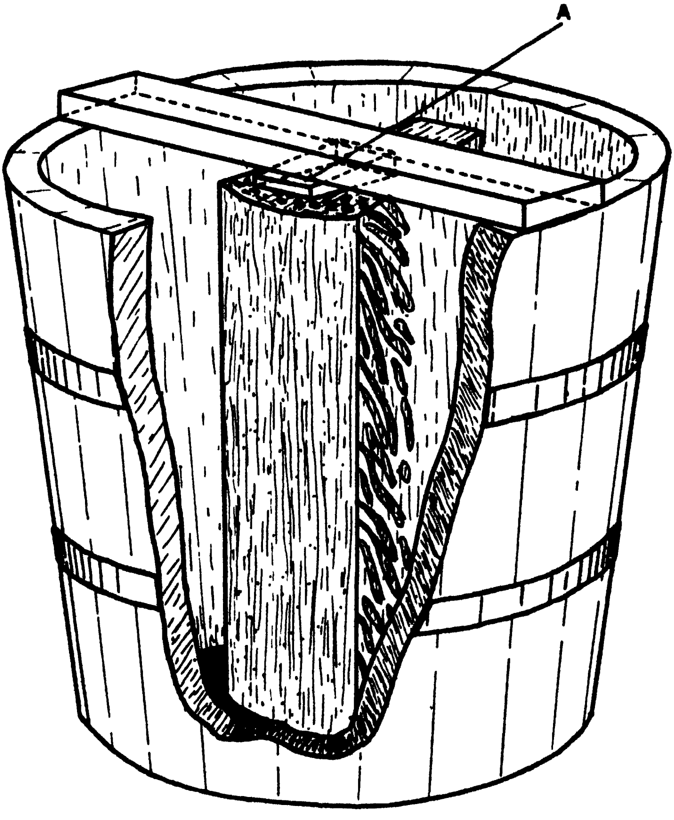


Fig. 1. Diagram of aquarium used in *Teredo* experiments.
A, wedge for holding specimen block.

The teredos used in the following experiments were obtained from piles pulled from the docks of the Sugar Refinery at Crockett. This form was determined as *Teredo navalis* by Kofoid (1921 and 1922).

OBSERVATIONS

EFFECT OF LOW SALINITY

Decrease in activity.—In considering the effect of reduced salinity on the activity and function of *Teredo navalis* a brief résumé of the normal mode of life of the organism is necessary. In the adult stage, the teredo is established in a long, slender burrow which it has drilled into a pile or other wooden object. The maximum size of the burrow is about five-sixteenths inch in diameter and twelve to sixteen inches in length. It is lined with pearly nacre except at the inner end in the region of the shell where boring activity goes on. The outer end of the burrow tapers to a minute opening through which two siphons are extended for the purposes of obtaining water containing food material and of ejecting excreta and wood chips resulting from boring activities. By means of these siphons, water is constantly circulated through the mantle cavity and burrow. The siphons are normally very sensitive and are quickly retracted when touched by a solid object. The organism is equipped at the siphonal end with a pair of small wedge-shaped pallets with which it may effectively plug its burrow when the siphons are drawn in. It is thus able to prevent intrusion of other animals and to avoid adverse conditions in the water outside the burrow by blocking the entrance of such water into its burrow.

When the salinity of the water becomes sufficiently low, the teredos draw in their siphons and plug up their burrows with the pallets. The point at which this occurs may be considered as the salinity below which full normal functioning is impossible. The following experiments were performed to determine this salinity.

Specimens were first acclimatized by placing them in standing straits water of 15 parts per 1000 salinity for two to four days. During this period a daily record was kept of the number of siphons extended from the specimen block, this number being taken as the original 100 per cent for the given specimen. The specimens were then changed to salinities of 0, 2, 4, 5, 6, 7, 8, 9, or 15 parts per 1000. A record was kept of the number of siphons extended from each specimen block during the periods of exposure (about three weeks) to these several lower salinities. Ten specimen blocks in individual aquaria were used in determining the average per cent of siphons extended by the teredos for each salinity tested. The number of siphons extended from each specimen block was recorded each day for a period of days after an apparent maximum had been reached which did not fluctuate markedly. Low records during this period, accompanied by unfavorable aquarium conditions, were discarded. These values were averaged for each specimen and the per cent of siphons extended was computed by comparison with the number of siphons originally extended from the same block in 15 parts per 1000 salinity. The average per cent for each salinity was computed from the average of the ten specimens. The per cent of siphons extended in 3 parts per 1000 salinity was determined separately under similar conditions, but during a shorter period of exposure.

The percentage of siphons extended from control blocks exposed during the experiment to a salinity of 15 parts per 1000—which should obviously be 100 per cent—was found to be only 92 per cent of that in earlier tests. If we assume that 8 per cent of the individuals were killed off by the conditions of life in the aquaria, we may raise all the values 8 per cent. This produces a curve represented by the dotted line in the graph (fig. 2) and is probably more typical than the curve obtained from the actual values computed from the records of the experiment without this correction.

The individual values from which the percentages for the curve were computed show deviation of 15 per cent from the mean in some cases, and at best the curve is only an approximation of actual conditions. Had it been possible to use a salinity nearer the optimum for the organism (probably about 20 parts per 1000) in determining the 100 per cent value for the graph, the position of the curve would have been changed to some extent. The decrease in per cent of siphons extended, between 15 and 9 parts per 1000 salinity, is very slight, however, and it may be expected that the increase between the salinity of 15 parts per 1000 and the optimum will be correspondingly small. None of these deviations will greatly alter the shape or position of the curve.

The curve indicates that the activity of the borers is nearly or quite as great in a salinity of 9 parts per 1000 as in higher salinities. In salinities below 9 parts per 1000, the per cent of functioning individuals becomes less, and decreases more rapidly as the salinity is decreased, until at 3 parts per 1000 there are no siphons extended. The curve descends rather gradually from 9 to 6 parts per 1000 and then slopes abruptly down to 4 parts per 1000. This rapid decrease in the number of siphons extended in salinities below 6 parts per 1000 indicates that, below this point, the vital functions are abruptly interfered with in a large number of individuals.

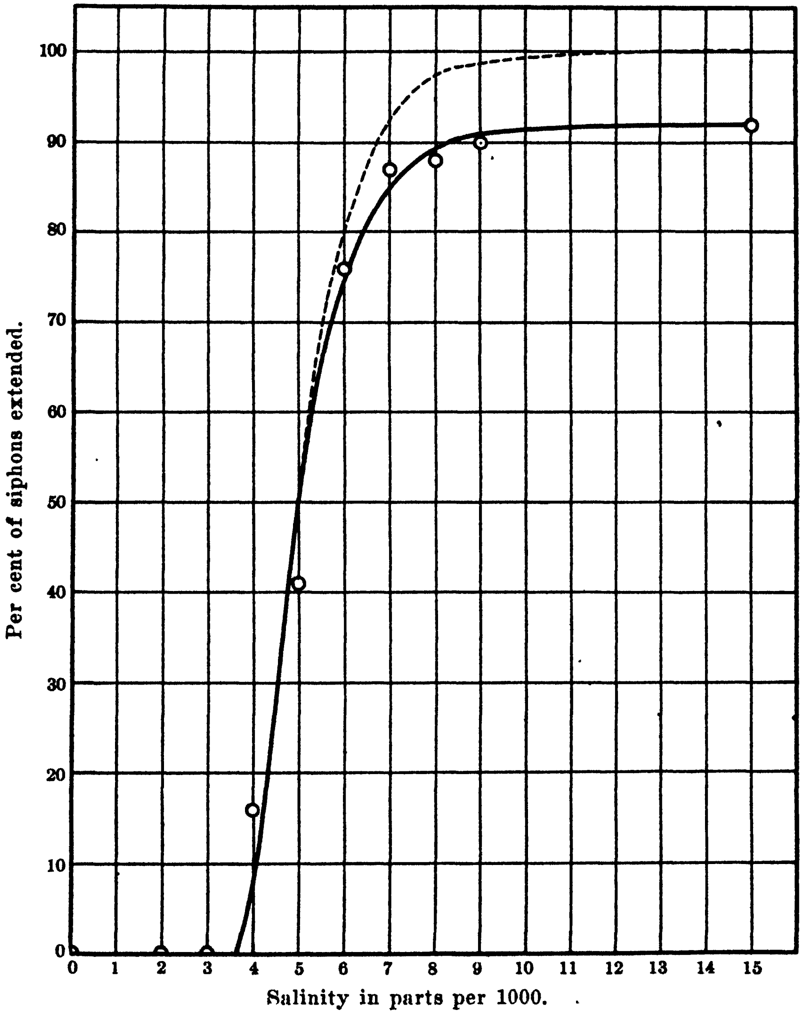


Fig. 2. Graph representing activity of *Teredo navalis* in water of various salinities.

The reduction of activity in these lower salinities is also indicated by the cessation of boring activity. The degree of this activity was estimated from the amount of chips ejected which collected on the bottom of the aquarium. In the salinity of 7 parts per 1000 and above, boring was found to be very active, in 6 parts per 1000 slightly less, in 5 parts per 1000 very rare, while in 4 parts per 1000 it was never observed in the aquaria.

There was also an accompanying change in the sensitivity of the siphons, these retracting rapidly in the salinities of 6 and 7 parts per 1000, moderately in 5 parts per 1000, and slowly in 4 parts per 1000.

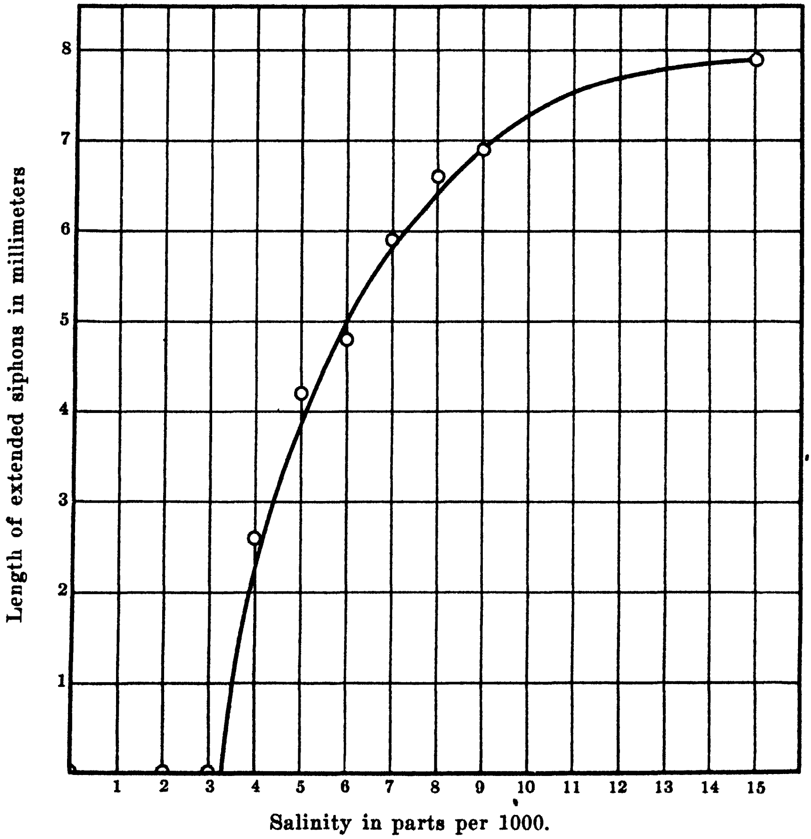


Fig. 3. Graph representing length to which siphons of *Teredo navalis* are extended in water of various salinities.

Again, there was a marked change in the length to which the siphons were extended, which is illustrated in figure 3. This curve shows a gradual decrease in the length of siphons, with decrease in salinity, the decrease per part per 1000 becoming greater as the salinity decreases.

The lethal salinity.—These observations indicate a general interruption of function in salinities below 6 parts per 1000, while below

4 parts per 1000 there is little or no activity. We may expect that above this critical range (4 to 6 parts per 1000) the teredos are able to continue to live and function as regards salinity, while below this range the organisms will die if exposed long enough. The salinity below which the average individuals are unable to live may be called the *lethal salinity.* This salinity has been more accurately placed at 5 parts per 1000 by the following experiments.

Teredos were exposed by splitting away the outer surface of the specimen blocks and breaking away the thin shell around the pallets, so that the animals were unable to plug themselves up in their burrows. Individuals exposed in this manner lived for eleven days in slowly running water of 5 parts per 1000 salinity, after which time the results were obscured by fouling of the aquaria. The activity of these teredos as manifested by the sensitivity of the siphons at the end of this time was equal to that of specimens in 6 and 15 parts per 1000 salinity, as is shown in table 1.

TABLE 1

ACTIVITY OF TEREDO NAVALIS, EXPERIMENTALLY EXPOSED, IN VARIOUS SALINITIES

Days	Salinity—parts per 1000							
	0	1	2	3	4	5	6	15
0	0	0	slow	slow	moderate	rapid	rapid	rapid
1	dead	0	slow	slow	moderate	rapid	rapid	rapid
2		dead	slow	slow	moderate	rapid	rapid	rapid
3			dead	0	slow	rapid	rapid	rapid
4				dead	slow	rapid	rapid	rapid
5					slow	rapid	rapid	rapid
6					0	rapid	rapid	rapid
7					dead	rapid	rapid	rapid
8						rapid	rapid	rapid
9						rapid	rapid	rapid
10						rapid	rapid	rapid
11						rapid	rapid	rapid

Individuals exposed to salinities below the lethal (5 parts per 1000) were killed off very rapidly, as is shown in table 2. The criterion of death used in these experiments was the first appearance of degeneration of the tips of the siphons. As soon as this degeneration appeared, the specimen blocks were changed to water of 15 parts per 1000 salinity, but the animals never revived after this degeneration had begun.

Harrington (1920) reports experiments on the effect of low salinities upon the larvae of a teredo, probably *T. norvegica.* He shows that these larvae were able to survive for at least a short time in salinities as low as 10 parts per 1000, although swimming was inhibited below 17.5 parts per 1000. No observations of this kind have been made on the larvae of *T. navalis.* Since *T. norvegica* is usually found in open sea water (i.e., water of 35 parts per 1000 salinity or thereabouts), however, it is probable that the larvae are less adapted to low salinity than are the larvae of *T. navalis,* which inhabits brackish waters. It may be expected that the larvae of the latter form might be able to live in approximately the same salinities as the adult.

TABLE 2

SURVIVAL OF TEREDO NAVALIS, EXPERIMENTALLY EXPOSED, IN VARIOUS SALINITIES

Salinity parts per 1000	Days of survival	Average temperature in degrees C°	Remarks
0	1	17	2 determinations
1	2	17	1 determination
2	3	17	1 determination
3	4	16	1 determination
4	7	17	1 determination
5		17	Teredos still active at end of 11 days.
6		17	
15		17	

NATURAL PROTECTION AGAINST UNFAVORABLE SALINITY

Although teredos exposed by splitting away the block around the pallets were soon killed when placed in salinities less than 5 parts per 1000 (see table 2), individuals in specimen blocks which had not been exposed in this manner lived for much longer periods in the same salinities. Table 3 gives the per cent of organisms surviving various periods of exposure to salinities of 0 and 2 parts per 1000.

Table 4 gives comparative results from tables 2 and 3, showing that in the same salinities, unexposed teredos lived much longer than exposed individuals. The organisms therefore received some protection from their burrows, through their ability to prevent the entrance of water from the outside by plugging the burrow entrance with the pallets when the salinity of the water fell below the danger point (5 parts per 1000), and at the same time to retain a quantity of salt water within their burrows.

Factors limiting protection.—We may expect that if the water within the burrow were diluted to a point much below the lethal salinity (5 parts per 1000) the teredos would be killed, since the animals die in a short time when directly exposed to water of less salinity. Such a process of dilution is indicated by the following experiment.

TABLE 3

SURVIVAL OF TEREDO NAVALIS IN STANDING WATER* OF LOW SALINITY IN AQUARIA

Salinity† parts per 1000	Days exposed	Per cent of siphons extended in sea water after this period	Remarks
0	7	100	....
0	10	100	....
0	15	50	....
0	16	15	....
0	18	30	....
0	21	5	....
0	24	0	Result from 4 specimens
2	13	100	....
2	15	100	....
2	18	100	....
2	21	33	....
2	22	32	Average of 3 specimens
2	24	22	Average of 2 specimens
2	26	0	....

* Water renewed every two days by passing stream of same salinity through aquaria for a few moments.

† Specimens acclimatized in 15 parts per 1000, and changed directly to lower salinities.

A specimen block containing teredos was removed from water of 15 parts per 1000 salinity and placed above water in a closed aquarium functioning as a moist chamber. In this way, evaporation of the water in the wood was restricted, but no dilution of the water in the burrows was possible. At the end of twenty-two days, the specimen block was placed in salt water and approximately 50 per cent of the original number of teredos extended their siphons. This was a greater survival than that in water of 0 and 2 parts per 1000 salinity for the same period of time. Table 4 shows the survival periods under different experimental conditions.

Since at the end of twenty-two days a greater percentage of teredos survived in the block not directly surrounded by water than in the blocks exposed to water of either 0 or 2 parts per 1000 salinity, we may assume that in the latter case the water within the burrows was diluted by the fresh water from the outside.

TABLE 4

SURVIVAL OF TEREDO NAVALIS UNDER VARIOUS EXPERIMENTAL CONDITIONS IN AQUARIA

Conditions	Salinity	Days exposed	Per cent of individuals surviving
Teredos exposed by cutting away mouth of burrow	0	1	0
	2	3	0
Unexposed teredo	0	21	5
	2	22	32
Unexposed teredo, block above water in closed aquarium		22	50

The process involved in this dilution of the water in the burrow is probably one of diffusion through the wood of the pile and perhaps between the pallets at the mouth of the burrow. It is also possible that the organisms may continue to draw in small quantities of water through their siphons, thus gradually diluting the water in the burrow; but this is not probable since it was found that teredos were killed more rapidly by running fresh water than by standing fresh water, which could hardly be explained by such a process. The above observation is more readily explained on the basis of diffusion, as the speed of this process would be increased by motion and change of water. The following experiment shows some results obtained with specimens in running water.

A series of aquaria was arranged so that currents of water of three different rates of flow could be passed through them. The rates of flow were not accurately measured, but had the following relation: $A > B > C$. A was the discharge of a three-quarter inch pipe, C a flow of approximately five gallons per hour, and B intermediate between these currents. Specimen blocks containing teredos were exposed in these aquaria and in aquaria containing standing fresh water. Two other specimens were prepared from ordinary specimen blocks by covering the split surfaces and cut ends of the block with a thin coating of paraffin. These specimens were exposed simultaneously with the untreated specimens in aquaria through which currents B and C were passing. All the specimens contained approximately the same number of live teredos at the beginning of the run. After seven days the specimens were changed to water of 15 parts per 1000 salinity. Table 5 gives the approximate number of individuals surviving under the various conditions.

TABLE 5

SURVIVAL OF TEREDO NAVALIS IN RUNNING AND STANDING FRESH WATER

Rate of current*	Number of individuals alive at end of 7 days		Mean temperature in degrees C
	Cut surfaces paraffined	Untreated	
A		0	19
B		0	19
C		30	16
C		30	11
still water		50	8
still water		60	8
B	15		19
C	30		16

* A > B > C.

Table 5 shows that the survival was greater in standing water than in running water, and greater in slowly running water than in swiftly running water. Specimens having the cut surfaces protected by a coating of paraffin, and therefore having less surface exposed for diffusion of water, show a greater survival than untreated specimens. The explanation of the dilution of the water in the burrow by a process of diffusion through the wood accounts for the above results, since the rate of diffusion would be expected to increase with the rate of flow of the current. This would shorten the time necessary for dilution of the water in the burrow, a condition which would be followed by the death of the teredos. The speed of such a process would also be decreased by reduction of the surface of the specimen by covering the cut surfaces with paraffin.

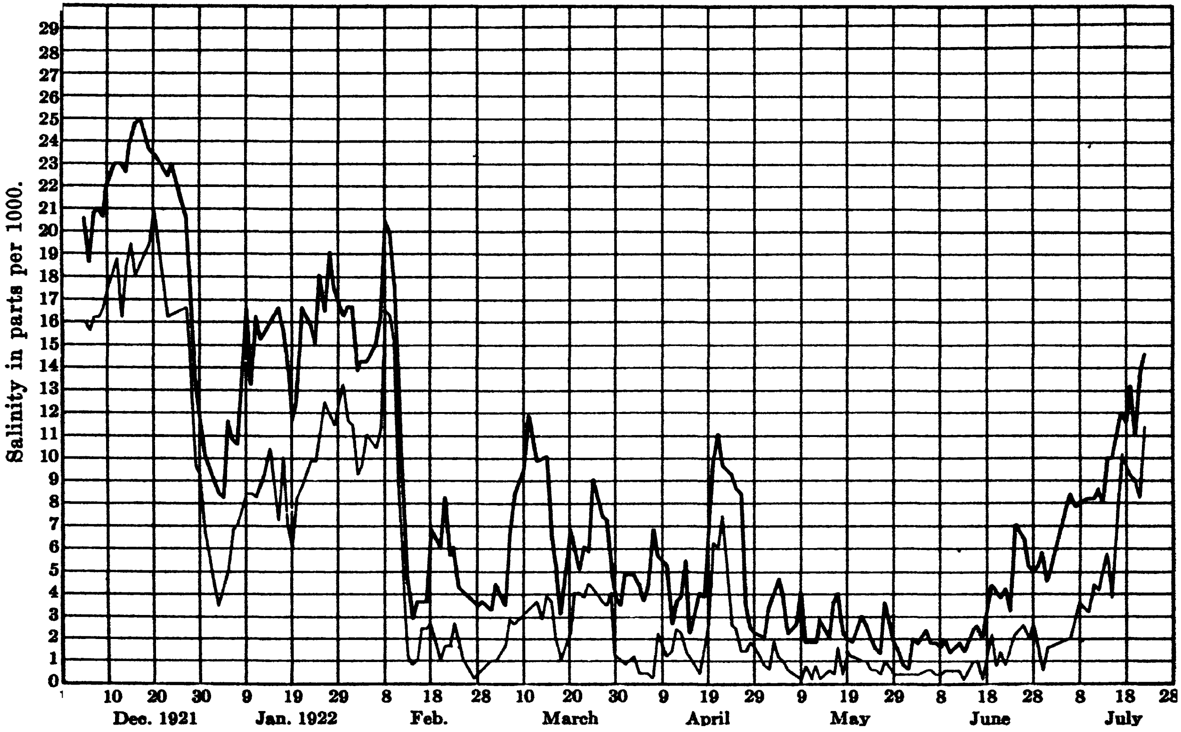
Table 3 shows that teredos lived longer in specimen blocks in water of 2 parts per 1000 salinity than in zero salinity. This may be due to the fact that diffusion takes place less rapidly between solutions nearer the same concentration than between solutions having a greater difference of concentration. Thus the dilution of the water in the burrow would take place more slowly when the blocks were surrounded by water of 2 parts per 1000 salinity than when surrounded by zero salinity and the teredos would survive for a longer period.

Teredos in the piles at Crockett have survived a greater period of low salinity during the past season than have the teredos under any conditions of low salinity in the aquaria (see tables 3 and 6). The short period of survival in the latter case may be due, however, to the greater relative surface exposed for diffusion in the specimen blocks than in piles. Besides having their cut surfaces exposed in most cases, these blocks were scrubbed free of barnacles and other marine growths which cover the exterior of all piles. Thus there was a relatively large surface exposed for diffusion, including the face of the block, the split surfaces, the open ducts of the wood at the cut ends, and the very large surface exposed by the opening up of many burrows in cutting the block. As is shown in table 5, more toredos survived low salinities when the cut surfaces of the blocks were covered with paraffin although this covering did not adhere closely in some places and was thus an imperfect seal. There must also be a slight leakage through the pallets although they fit tightly and form a very effective plug.

At times during the period of low salinity at Crockett, when several piles were pulled at the same time from the same locality it was found that there was a marked difference in survival in teredos from different piles. With conditions apparently the same for all the piles, it seems reasonable to assume that the difference of survival was due to differences in the porosity of the wood in the piles, which would allow diffusion to take place more rapidly in some piles than in others. This phenomenon is difficult to account for in any other way.

Although the above evidence is far from conclusive, the explanation given seems to be the only one which accounts for some of the phenomena observed. Hence it seems reasonable to assume that when plugged up in their burrows teredos are killed only by a gradual reduction in salinity of the water in the burrow, and that this process takes place by diffusion through the wood.

Fig. 4. Graph of salinity of water at Crockett, California, during the season of 1921–1922.
Legend: Heavy lines, Maximum salinity.
Light lines, Minimum salinity.



SURVIVAL PERIOD OR LETHAL STRETCH

An explanation of the above process becomes important if we wish to predict the survival of teredos by observation of the salinity of the water from day to day. In a daily salinity record such as is represented by figure 4, periods of survival or lethal stretch must be measured as periods during which the salinity remains below 5 parts per 1000, as when the salinity rises above this point the teredos are able to take in a fresh supply of salt water. Fluctuations of salinity during such periods must influence the rate of dilution of the water in the burrow, but are of little importance in predicting the survival of the organisms.

During the past season a daily record has been kept of the salinity of the water in Carquinez Straits. Samples have been taken during the day at high and low tide, from the surface and from a depth of fourteen feet. Samples have been taken at two points about one-eighth mile apart, as it was found that differences in the salinity at these two points occurred frequently because of currents and eddies. In preparing the salinity graph, figure 4, the maximum and minimum records from all the samples for each day have been plotted.

TABLE 6

SURVIVAL OF TEREDO NAVALIS IN PILES AT CROCKETT DURING PERIOD OF LOW SALINITIES, SEASON OF 1921–1922

Date pile was pulled	Period of days below			Per cent of individuals surviving
	5 parts* per 1000	4 parts† per 1000	3 parts‡ per 1000	
May 13	16	.....	....	100
May 18	21	1	....	90
June 5	39	19	9	50
June 12	46	26	16	40
June 26	50	33	23	10
July 29	58	33	23	10

* Salinity remained below 5 parts per 1000 from April 26 to June 24.

† Salinity remained below 4 parts per 1000 from May 17 to June 19.

‡ Salinity remained below 3 parts per 1000 from May 27 to June 19.

Reference to figure 4 shows that during the past season (1921–1922) the salinity remained below 5 parts per 1000 from April 26 to June 24, below 4 parts per 1000 from May 17 to June 19, and below 3 parts per 1000 from May 27 to June 19.

Table 6 shows the survival of teredos in piles pulled from the fender lines at Crockett, at intervals during the period of low salinity.

It appears from table 6 that 10 per cent of the borers survived a stretch of fifty-eight days of salinity below 5 parts per 1000. During May, however, several peaks occurred which reached salinities of 4 parts per 1000 or more (see fig. 4).

Our experiments have indicated 5 parts per 1000 as the average lethal salinity, but it was also observed (fig. 2) that a small proportion of the organisms could extend their siphons and carry on their vital functions for some time in a salinity of 4 parts per 1000. It may be possible that this small proportion of the organisms are able to renew the water in the burrow when the salinity rises to 4 parts per 1000, and that this may account for the nearly 100 per cent survival of the organisms during the month of May (see table 6). The slight mortality during this time (May 13 to May 18, table 6) may have been due to the death of some of the weaker individuals. Since samples were not always taken at the major tide of the day, however, it is probable that the salinity may have reached 5 parts per 1000 on some of the days when our salinity record shows only 4 parts per 1000. Thus it may be advisable to assume 4 parts per 1000 as the critical salinity in interpreting the results given in table 6. The real stretch seems to have occurred during the period when the salinity was below this point, since, in the piles examined, 50 per cent of the borers were dead at the end of nineteen days, 40 per cent at the end of twenty-six days, and 90 per cent at the end of thirty-three days. This corresponds more closely with some of the results obtained in the aquaria (see table 3).

From this interpretation of the results an estimate of one and one-half months of a salinity below 4 parts per 1000 as the period required for the destruction of all the teredos seems reasonable. The borers are extremely resistant, however, and it may be that the greater period of fifty-eight days (recorded of a salinity below 5 parts per 1000) is not enough to exterminate them wholly. Estimates of the lethal stretch must be very conservative at present and only careful observation for several years can give reliable results.

It may be noted that there was apparently no further mortality between June 26 and July 29, during which period the salinity was very frequently above 5 parts per 1000.

During the years 1859–1869, Dutch investigators made observations upon *Teredo navalis* along the coast of the Netherlands and in the Zuider Zee. Frequent records were taken of the salinity at various points, and these are noted in a series of reports (Vrolik, *et al.*, 1860–1864; Van Oordt, *et al.*, 1865, 1869). From these records it appears that the lowest salinities occurred during the year 1861 at Niewendam on the Ij. During that year the salinity averaged 7.67 parts per 1000 of sodium chloride (8.39 parts per 1000 total salts). The lowest record for the year was 6.17 parts per 1000 sodium chloride (6.74 parts per 1000 total salts). In this year the salinity remained below 9 parts per 1000 from May 1 to December 31, and during the year the borers were plentiful in the region. *Teredo navalis* has survived much lower salinities at Crockett than those recorded at Niewendam. It appears that the salinity was never low enough at the latter place to exterminate the borers, although it may have reduced their activity during certain periods.

RESISTANCE TO SUDDEN CHANGES IN SALINITY

Reference to figure 4 shows that the teredos at Crockett experienced many sudden changes of salinity prior to the long period of low salinities in May and June. Differences of four to six parts per 1000 between the maximum and minimum salinities for the same day occur frequently. There was a drop of seven parts per 1000 on two days in December and in February a drop of thirteen parts per 1000 in three days. The borers survived all the changes which occurred prior to the prolonged period of low salinity in May and June.

It has been observed, in the aquaria, that teredos which have been forced to plug up their burrows because of reduced salinity revive very rapidly when placed in salt water. One hour is generally sufficient for resumption of activity by all the living individuals, the siphons being extended and boring activity begun by the end of this time.

SUMMARY

Experimental observations on the activity of *Teredo navalis* in various salinities, as manifested by the extension of the siphons, indicate that the organism is normally active in salinities as low as 9 parts per 1000, and below this point the activity decreases with decrease in salinity. Below a salinity of 7 parts per 1000, the proportion of active individuals decreases very rapidly until at 3 parts per 1000 no teredos are extending their siphons.

The average lethal salinity for *Teredo navalis* has been determined experimentally as 5 parts per 1000.

Teredos obtain some protection from water of a salinity below the lethal (5 parts per 1000) by stopping the mouth of the burrow with the pallets and thus preventing the entrance of water from the outside. At the same time, a supply of salt water is held within the burrow. It is probable that the salinity of this retained water is gradually diluted by diffusion through the wood and that the organisms are finally killed in this way. If, however, the salinity rises above 5 parts per 1000 before the salinity of the retained water becomes diluted enough to kill the organism, it will be able to obtain a fresh supply of water and survive for a longer period.

A period of thirty-three days below 4 parts per 1000 salinity has destroyed 90 per cent of the teredos in piles at Crockett. Immediately prior to the above period, an interval of twenty days below 5 parts per 1000 salinity occurred, but the record shows frequent peaks of 4 parts per 1000 salinity or more during this interval. It is probable that the salinity actually rose to 5 parts per 1000 at some time during the days on which these peaks occurred, since the water samples were not always taken at the major tide. Thus it seems reasonable to measure the period of survival as the period below 4 parts per 1000 salinity, i.e., thirty-three days. The period necessary to destroy the surviving 10 per cent of the organisms is impossible to determine definitely at present.

Teredos show remarkable recovery from sudden changes of salinity in aquaria. They have also survived great changes in the salinity of the bay water during the past season.

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QUANTITATIVE STUDIES ON INSHORE MARINE DIATOMS AND DINOFLAGELLATES OF SOUTHERN CALIFORNIA IN 1920

BY

WINFRED EMORY ALLEN

(Contribution from the Scripps Institution for Biological Research of the University of California)

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INTRODUCTION

This paper is the second of a series of papers dealing with this subject, the first of which covered the work done in the last four months of 1919 at the pier belonging to the Scripps Institution for Biological Research of the University of California at La Jolla (Allen, 1922). The present report covers material similar to that described in the first paper. This material was taken by the same methods and equipment and handled and studied in a similar way. The only difference is that in this series a part of the material was obtained from another station (Pt. Hueneme) at the eastern end of Santa Barbara Channel about one hundred miles northwest from La Jolla, located in latitude 34° 08′ 38″ North and longitude 119° 12′ 40″ West; also, this material was taken by a pier employee (Mr. B. E. Garner) on six mornings of each week as he found opportunity in connection with his regular employment.

Since the work of this year was carried on in the same way as that described in the above mentioned report for 1919, it is assumed that preliminary discussion is unnecessary and that we may properly enter at once upon direct consideration of the material.

GENERAL DISCUSSION

Through the first eight months of 1920 collections were taken at intervals of twelve hours at the La Jolla pier. Since such a series cannot properly be compared with one taken at different intervals, this series may best be segregated and discussed first merely as a twelve-hour series. The morning catches can then be properly included in a separate discussion of the twenty-four-hour series taken at both stations.

THE TWELVE-HOUR SERIES

Attention will here be limited to features peculiar to the twelve-hour series. These features are all connected with the question as to whether larger numbers of diatoms and dinoflagellates were taken in morning or in evening catches. This question has already received some attention (Allen, 1922).

Summaries now available for the twelve months from September 1, 1919, to September 1, 1920, show a rather marked difference in diatoms and dinoflagellates, the former being taken in larger numbers in morning catches, the latter in evening catches. This fact is best shown by comparing single catches with the two nearest, i.e., twelve hours earlier and twelve hours later. Thus, in the case of diatoms, in the twelve months, 146 morning catches were larger than the two nearest evening catches while only 62 evening catches were larger than the two nearest morning catches. But, in the case of dinoflagellates, only 86 morning catches were larger than the two evening catches while 135 evening catches were in excess of the two morning catches.

Similar differences appear when comparing catches with the last one preceding them. Thus, in the twelve months, each of 224 morning catches of diatoms exceeded that taken the evening before and only 136 of the evening catches exceeded those taken respectively the mornings before, while four were equal. But, in the case of dinoflagellates, only 168 of the morning catches exceeded those respectively of the preceding evenings, while 198 of the evening catches exceeded those respectively of the preceding mornings, four being equal.

Such numerical differences obviously suggest the possibility that diatoms generally tend to reproductive activity at night rather than in the daytime when their energies are occupied in photosynthesis. It also appears that dinoflagellates are not thus inclined. This difference in the groups strongly indicates that their characteristics are so different that they cannot properly be considered together as a photosynthetic assemblage. It also indicates the justice of Kofoid and Swezy's assertion (Kofoid and Swezy, 1921) that the holophytic aspect of the activities of dinoflagellates has been over-rated.

In addition to these points there are the repeated evidences that distribution of organisms in sea water is not uniform. There were very few days in the whole year in which catches twelve hours apart showed approximately the same numbers and these few days were all found to be in periods of very low production.

THE TWENTY-FOUR-HOUR SERIES

In working over the records of catches at both La Jolla and Pt. Hueneme it was found necessary to use some unit of time greater than the day and less than the month. In some ways five-day units seem to be most satisfactory, but they are not in common use and on account of omission of Sunday collecting at Pt. Hueneme this unit could not be applied. It was therefore decided to adopt the week as the standard unit in this kind of discussion. This unit is also desirable because of its use by our hydrographic workers and by the United States Weather Bureau.

SEASONAL VARIATIONS IN NUMBERS

One of the first questions to be raised concerning a series of catches running over a period of a year is that about seasonal variations, the more obvious of which may be expected to be variations in numbers and variations in species or representative forms. As to the first it is generally understood that maximum production occurs in the late spring or early summer and that there is also a rise of production in autumn after a decline in late summer. While our 1920 evidence does not contradict this view, it does modify it to a considerable extent, in that the numerical distribution is not thus limited at either station.

The most marked departure from this expectation is to be noted in the La Jolla series of diatom catches, graphically shown in figure 1 and recorded in the first column of table 1. Here on January 29 was begun a very remarkable increase of production which was well sustained for a period of eight weeks, after which the markedly productive periods, distributed in five groups, did not endure more than three weeks. In fact, the period of heaviest production, which came early in May, lasted only a little more than a week and the period of next heaviest production was largely confined to the last week of June and the first week of July. Evidently the moderate pulse of production occurring in September was the only one meeting ordinary expectations.

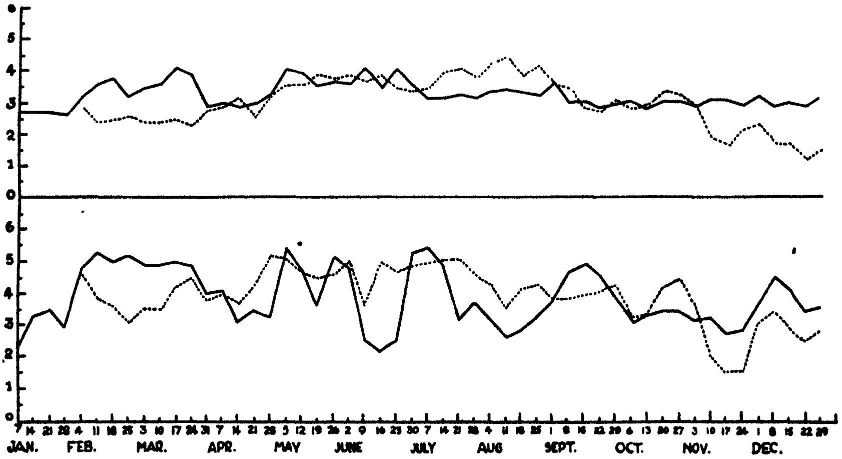

Fig. 1

Unfortunately the Pt. Hueneme series was not opened until February 1 and it may have missed most of a period of heavy production, a part of which is indicated in the case of diatoms for the week ending February 4 (fig. 1 and table 1). At any rate the heaviest production of the year occurred in the last week of April and the first week of May, a date also somewhat earlier than usually expected. The period of best sustained production was through most of June and July which is fairly near to expectation. There is, however, no marked pulse in autumn.

Since the numerical distribution of the dinoflagellates at the two stations was somewhat similar to that just described for the diatoms, it is not necessary to discuss them in detail. Figure 1 and table 1 give the essential points. Note that the numbers of dinoflagellate cells are on the average smaller (usually much smaller) than the numbers of diatom cells throughout the year at both stations.

TABLE 1

DAILY AVERAGE NUMBERS OF CELLS PER LITER IN SEVEN DAY PERIODS THROUGH 1920

No. of week	For week ending		Diatoms		Dinoflagellates	
			La Jolla	Pt. Hueneme	La Jolla	Pt. Hueneme
1	January	7	231	....	601	....
2		14	2,510	....	570	....
3		21	3,412	....	554	....
4		28	1,000	....	430	....
5	February	4	67,853	45,760	1,913	800
6		11	200,301	8,712	4,900	307
7		18	105,852	4,619	6,898	389
8		25	161,255	1,259	1,669	448
9	March	3	81,570	3,557	3,345	309
10		10	99,648	3,815	4,192	266
11		17	110,014	18,451	12,942	344
12		24	94,858	33,543	8,347	245
13		31	10,183	6,357	965	789
14	April	7	13,162	11,584	1,056	864
15		14	1,346	5,070	987	1,760
16		21	3,837	20,755	1,138	464
17		28	2,436	161,299	2,168	2,416
18	May	5	364,723	130,851	13,045	4,528
19		12	65,408	52,756	10,997	4,176
20		19	4,823	31,672	4,217	8,600
21		26	185,253	45,269	5,582	7,178
22	June	2	67,522	123,120	4,202	9,296
23		9	407	6,032	15,157	6,035
24		16	183	122,100	3,911	8,475
25		23	320	58,716	15,490	3,221
26		30	232,867	86,091	4,185	2,752
27	July	7	341,851	104,328	1,774	3,781
28		14	85,416	128,819	1,641	10,503
29		21	1,751	142,445	2,290	14,840
30		28	6,893	41,630	1,774	7,746
31	August	4	1,742	23,136	2,602	24,195
32		11	617	4,107	3,750	35,691
33		18	878	17,507	2,560	8,861
34		25	2,286	24,667	2,121	16,589
35	September	1	6,991	8,088	5,557	6,303
36		8	55,832	8,913	1,497	3,611
37		15	102,219	11,619	1,271	816
38		22	43,173	15,179	958	691
39		29	8,436	20,987	1,099	1,357
40	October	6	1,739	2,446	1,367	904
41		13	2,811	3,019	843	1,021
42		20	3,226	20,369	1,271	2,736
43		27	3,393	38,837	1,374	2,195
44	November	3	1,989	5,984	1,179	1,029
45		10	2,183	133	1,870	110
46		17	706	47	1,613	61
47		24	921	41	1,147	171
48	December	1	6,020	1,365	2,343	265
49		8	42,427	3,816	1,057	75
50		15	17,982	1,175	1,337	67
51		22	3,973	401	1,125	22
52		29	4,039	907	2,165	40

VARIATIONS IN KINDS OF ORGANISMS

It might be expected that with such clearly marked periodicity of production, especially as shown by diatoms at the La Jolla pier (fig. 1 and table 1), there would be prominent shifts in the specific characters of the diatom and dinoflagellate populations. But for this year at least such distinctions do not appear.

At the La Jolla pier there were eighteen weeks in 1920 in which production of diatoms might be said to be conspicuous (although not always heavy) and in these eighteen weeks only eight forms were for any week included in the three most numerous. One of these was the catchall assemblage called *Chaetoceras* sp. which was necessarily indefinite in application. Of the seven species segregated *Bacteriastrum varians* Lauder was second for two successive weeks; *Chaetoceras affine* Lauder was second for one week and third for four weeks; *Chaetoceras curvisetum* Cl. (including *Ch. debile* Cl.) was first for three weeks, second for two, and third for three weeks; *Chaetoceras scolopendra* Cl. was second once and third once; *Leptocylindrus danicus* Cl. was first for two successive weeks; *Nitzschia seriata* Cl. was third in nine weeks, second in four, and third in two weeks; and *Skeletonema costatum* Grev. was second in three and third in two weeks.

Omitting the indefinite group *Chaetoceras* sp., there were only three forms in conspicuous abundance (averaging more than 50,000 per liter for one or more weeks) at the La Jolla pier in 1920, viz., *Nitzschia seriata* Cl., *Chaetoceras curvisetum* Cl., and *Leptocylindrus danicus* Cl. The prominence of the last named was confined to the last two weeks in May. One or both of the other two species was conspicuous at all seasons. Such evidence does not indicate any great tendency of the diatom population to change in character from one season to another.

At Pt. Hueneme the evidence of such change is a little stronger. Six forms of the eight which appeared amongst the first three in one or more productive weeks were the same as at La Jolla. *Bacteriastrum varians* Lauder and *Leptocylindrus danicus* Cl. did not reach prominence, but *Thalassiosira baltica* Grun and *Eucampia zoodiacus* Ehr. did. The former was very prominent for two weeks at the end of April and beginning of May, and the latter was most prominent during the second week in July. Aside from *Chaetoceras* sp. these two were, with *Nitzschia seriata* Cl. and *Chaetoceras curvisetum* Cl., the conspicuous forms at Pt. Hueneme.

So far as we know at present *Nitzschia seriata* Cl. and *Chaetoceras curvisetum* Cl. may constitute a fairly stable portion of the diatom population in the southern California region and forms such as *Bacteriastrum varians* Lauder, *Leptocylindrus danicus* Cl., *Eucampia zoodiacus* Ehr., and *Thalassiosira baltica* Grun may be more typically variable, or fluctuating or delicately responsive in character, and so more truly indicatory of the incidence and influence of changes in their environment.

Dinoflagellates showed general features of seasonal distribution of species essentially similar to those of diatoms. At La Jolla eight forms attained prominence in one or more of the productive periods sufficient to place them amongst the first three species in one or more weeks. One of the most prominent of these eight was a catchall assemblage called *Gymnodinium* sp. which may at times have included many other minute organisms. In that respect the group is even more unsatisfactory than *Chaetoceras* sp. Two of the other prominent forms, *Peridinium cerasus* Pauls. and *Peridinium minutum* Kof., were often indistinct and hence not satisfactorily identified. Several small species may have been recorded under those designations at one time or another.

Of the five prominent species identified with approximate accuracy, *Prorocentrum micans* Ehr. was decidedly the most persistent, reaching third place or better in nine out of the ten noticeably productive weeks. In addition to it *Ceratium furca* (Ehr.) Clap. u. Lach. and *Peridinium minutum Kof.* were notably abundant in one or more weeks.

At Pt. Hueneme fourteen weeks were relatively productive in which six forms, besides *Gymnodinium* sp., were amongst the three most abundant in one or more weeks. Of these only four reached numbers large enough (3000 per liter or more) to be considered distinctive. They were *Prorocentrum micans* Ehr., listed amongst the first three in all of the fourteen weeks; *Ceratium furca* (Ehr.) Clap. u. Lach. amongst the first three in four weeks; *Ceratium tripos* (O.F.M.) Nitzsch. amongst the first three in three weeks; and *Peridinium minutum* Kof. amongst the first three in seven weeks.

As in the case of diatoms it appears probable that one or two species are relatively stable in the region studied and that others are more sensitive to environmental changes or less able to make their own way. If this be true, at both La Jolla and Pt. Hueneme *Prorocentrum micans* Ehr. is evidently the typically stable species and *Ceratium furca* (Ehr.) Clap. u. Lach. shows similar tendencies. For this particular year it is clear that dinoflagellates present even less evidence than diatoms that there is a regular seasonal sequence in species.

SPECIES AND GENERA

Since I have already in former papers (Allen, 1921, 1922) designated the more common forms and discussed certain characteristics exhibited by them in this region it is scarcely necessary to include such details in this paper or any other until our observations have been carried over enough years and localities to make such discussion more nearly accurate instead of merely suggestive. We have in expectation a period of at least five years of pier collections in this series which we hope may give ground sufficient for a revised statement of details.

NOTE.—In accordance with the recent movement toward condensation of scientific matter detailed discussion has been almost entirely omitted from this paper and (still more important) 228 pages of tables have been omitted. No place of deposit of such tables has yet been designated so that it will be necessary for those desiring further information to write to the Director of the Scripps Institution at La Jolla, California.

SUMMARY AND CONCLUSION

1. It is certain from the excellent condition of the series from Pt. Hueneme that a trustworthy untrained man can do satisfactory work in plankton collecting by our measured water method.

2. As is shown in table 1 the average *number* of diatoms is much greater through most of the year than is the average number of dinoflagellates. The ratio at La Jolla was nearly 1/15 and at Pt. Hueneme nearly 1/8. Actual nutritive values of the two populations may have been somewhat similar.

3. As is shown in the discussion of morning and evening catches, the behavior of diatoms and dinoflagellates is not enough alike to warrant my former practice of discussing them together as a photosynthetic assemblage, since the morning catches of diatoms exceeded those of the evening while the evening catches of dinoflagellates exceeded those of the morning.

4. The studies of this year have yielded continued evidence that distribution of organisms in sea water is not uniform.

5. Seasonal variations in numbers at La Jolla did not closely accord with the probabilities mentioned by various observers since a period of sustained productivity came much earlier than might have been predicted in the case of both diatoms and dinoflagellates. There was also some indication of such departure at Pt. Hueneme.

6. At neither station was there much variation in the kinds of diatoms and dinoflagellates according to time of year. There was some suggestion of the possibility that two or three forms are relatively stable and constant and that one or two other forms may gain prominence through marked responsiveness to seasonal differences.

7. From my experience in the study of this series it is increasingly evident that we not only need long, continuous series of observations in as many localities as possible but that we greatly need enormous increase of such observations in many complementary and supplementary lines.

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STYLARIOIDES PAPILLOSA, SP. NOV., A NEW ANNELID FROM THE SAN DIEGO REGION

BY

CHRISTINE E. ESSENBERG

(Contribution from the Scripps Institution for Biological Research of the University of California)

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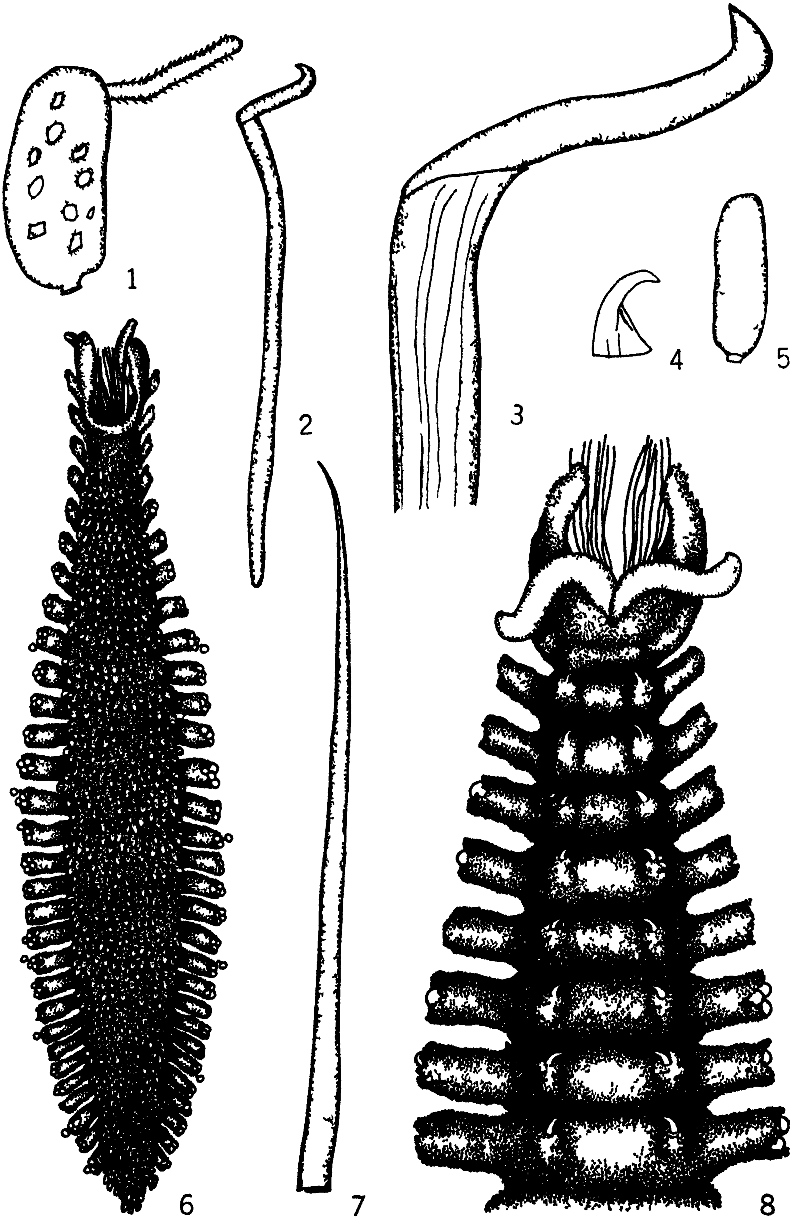
STYLARIOIDES PAPILLOSA, SP. NOV., A NEW ANNELID FROM THE SAN DIEGO REGION

BY
CHRISTINE E. ESSENBERG

The polychaetous annelids of the family Stylarioidae are apparently rare in waters of the Pacific Coast of North America. The large annelid collection of the University of California at Berkeley does not contain any specimens of this family.

In the San Diego region, where shore collections are frequently made at low tide, a single specimen has thus far been found by the author and is evidently a new species which we designate *Stylarioides papillosa.*

This species is of a gray-brown color and is difficult to detect in mud where it lives, except by its wriggling motion. The body is about 70 mm. long, slightly flattened on the ventral side, tapers gradually toward both ends, and terminates bluntly at both. It has forty segments, which are visible only from the ventral and lateral surfaces. On the convex dorsal surface they are obscured by the abundance of long, finger-like projections (fig. 1). The mouth is surrounded by two long, green palps and by fourteen or more grass-green, long branchiae (figs. 1, 2). The parapodia are long in the living animal, with short papillae projecting even from their tips. In the preserved specimen the parapodia have contracted very much, so that they are hardly visible from the dorsal surface. There are two kinds of setae. The ventral setae, about two on each parapodium, are conspicuously large, compound, and hooked (figs. 3, 4, 6). The dorsal setae are long and slender. They are hardly visible in the living animal, being buried deeply in the parapodium (fig. 2). The dorsal projections, or villi, giving the animal a rough or spiny appearance, are of two kinds. Some are long, finger-shaped, attached to the body by a narrow neck (fig. 5); others are smooth and uniform in shape (fig. 8). These villi-like projections incline posteriad and between them are lodged grains of sand and mud, giving the animal the appearance of a moving piece of mud.



Stylarioides papillosa

Fig. 1. Villus. × 45.
Fig. 2. Ventral seta. × 45.
Fig. 3. Tip of ventral seta. × 320.
Fig. 4. Point of hook of ventral seta. × 320.
Fig. 5. Villus. × 20.
Fig. 6. Dorsal view. × 1.5.
Fig. 7. Dorsal seta. × 160.
Fig. 8. Ventral view of anterior portion. × 3.

Stylarioides papillosa has some resemblance to *S. plumosa* Chiaje (1828–1829) and to *S. flabellata* (McIntosh, 1915). It differs from both in various essential characteristics.

Its failure to be found in the many annelid collections from the Pacific Coast may be due to its remarkable adaptations and its protective coloring. Unless one makes a special effort to find it by pulling up the sea weeds under whose roots the animal lives, this polychaete would probably not be discovered.

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THE DIGESTION OF WOOD BY TEREDO NAVALIS

BY

WALTER H. DORE AND ROBERT C. MILLER

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THE DIGESTION OF WOOD BY TEREDO NAVALIS

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INTRODUCTION

Ever since the classical investigations of *Teredo* by Sellius in 1733, it has been debated periodically whether or not the destructive boring mollusks of this group derive any nutriment from the wood which they so effectively perforate. Sellius himself discussed the question (p. 108) without arriving at a definite conclusion. Reimarus (1773, pp. 55 ff.) expressed a negative opinion, which was shared by Home (1814, p. 373), who examined wood particles removed from the bodies of the animals and thought them to be unchanged by the digestive fluids. Baumhauer (1866, p. 19) states unreservedly that *Teredo* bores in wood, not for nutriment, but solely to secure a protected dwelling. Most recent writers, such as Sigerfoos (1908, p. 218), Moll (1914, p. 257), and Calman (1919, p. 12), although considering plankton the principal food of the organisms, admit the possibility that some nourishment may be derived from the wood. Bartsch, however, in a recent monograph (1922) inclines to the earlier view of non-utilization of the wood particles as food, suggesting (p. 4) with apparent seriousness that "the shipworm may simply indulge in a partial meal of this kind to have the comfortable feeling of a copious repast."

BIOLOGICAL CONSIDERATIONS

The arguments against utilization of the wood as food are several and varied. Certain near relatives of *Teredo* (*Pholas, Zirphaea,* and *Saxicava*) bore for protection only, in such substances as sandstone, limestone, shale, marl, and gneiss—materials which cannot be supposed to yield them any nourishment; these indigestible borings may even be found in considerable quantities in the digestive tract of the rock borers (Calman, 1919, p. 12), so that the presence of wood borings in the digestive tract of *Teredo* is of itself no proof of utilization of wood as food. The principal constituents of wood, cellulose and lignin, are notoriously resistant to digestive action, so that they pass through the digestive tract of many animals entirely unchanged by the enzymes there present. *Teredo* is equipped to take its food from the water as do other lamellibranchs; also, the inner end of a teredo's burrow is often closed off by the formation of a shelly cross-partition, and the animal may live for an indefinite period with no contact with the wood whatever. Finally, wood that has passed through the digestive tract of the animal is shown by microscopic study to have retained its cellular structure (pl. 18, fig. 1), and some investigators even claim to have identified the kind of wood by its odor and color, as stated by Moll (1914, p. 526). This writer remarks that it is hardly conceivable that action on the wood by the digestive fluids should not have changed it more.

In reply to these arguments it may be said that *Teredo* is one of the most highly specialized of the boring mollusks, and might be expected *a priori* to differ from its rock-boring relatives in its method of obtaining nourishment. Some other types of animal are known to derive nutriment from wood, notably the termites (Banks and Snyder, 1920, p. 94) and various wood-boring beetles; among the mollusks, certain snails are known to secrete enzymes which act upon cellulose (Billard, 1914, p. 566). It would be surprising if *Teredo* were entirely to neglect so proximate a source of food as is afforded by the wood particles passing through its digestive tract. While the animal does sometimes partition itself off anteriorly from contact with the wood, it does not ordinarily do this until well grown, and probably not until forced to cease boring by the honeycombed condition of the wood. As regards the wood's retention of its physical properties after passage through the digestive tract, we may refer to König's observation (1913, p. 1101) that when cellulose is dissolved from wood by means of strong acids, the residual lignin still possesses the original woody structure. Hence we should expect that the appearance of the wood under the microscope would not be materially changed, even though the cellulose, hemicelluloses, and soluble sugars were entirely removed.

The most potent presumptive evidence in favor of the digestion of wood by *Teredo* is found in the anatomical structure of the digestive tract. The stomach opens posteriorly into an expanded and elongated blind sac, the caecum, in which the wood particles swallowed during boring operations are accumulated, being then periodically emptied into the intestine, whence they pass into the anal canal and are ejected through the dorsal siphon. It seems improbable that so specialized an organ as the caecum should have no significance in the economy of the animal except as a temporary storage place for extraneous sawdust on its way to the outside. The anatomical evidence on this point will be treated by Lazier in a paper shortly to appear in this series.

CHEMICAL CONSIDERATIONS

Indirect evidence, however, must of necessity be inconclusive. The need of definite experimental proof has suggested an approach to the problem from the chemical point of view. It should be possible to determine experimentally (1) whether or not the enzymes of *Teredo* are capable of acting upon any of the constituents of wood, or (2) whether or not the wood particles are chemically changed in their passage through the digestive tract.

The first of these alternatives has been selected for investigation by Harrington (1921), who has shown, though not so conclusively as might be desired, that a certain enzyme or enzymes extracted from excised livers of *Teredo norvegica* will act on sawdust to produce glucose. Since the liver extract failed to reduce pure cellulose, Harrington concludes either that the enzymes were not present in sufficient concentration, or that action on the wood was limited to hydrolysis of the hemicelluloses, which are notably more easily broken down than pure cellulose, with the further alternative that "there may be other substances present in wood which are necessary as co-enzymes to the ferment in question."

The present writers would suggest the possibility that the liver enzymes are not the only digestive ferments acting in the intestinal tract of *Teredo;* there may be enzymes from the crystalline style (Nelson, 1918, pp. 93, 107) or other parts of the digestive system, which are the necessary co-enzymes in the process of hydrolysis of wood. It is entirely within the limits of probability that a fluid capable of hydrolyzing cellulose may be poured out in the region of the foot, so as to serve the double purpose of softening the wood to facilitate boring and of preparing a part of it for absorption.

It is hoped that Harrington will press these interesting physiological investigations farther along the lines he himself has suggested. In the meantime, it has seemed to the present writers that very definite results might be obtained from the second method of investigation mentioned above, namely, by extracting and comparing the chemical constitution of the borings with that of the original wood, thus arriving at both a qualitative and quantitative determination of such changes as may take place during passage of the borings through the digestive tract.

Analysis of wood particles removed from the excised caecum would be open to criticism on more than one count. Aside from consideration of the almost impossible number of teredos that would be required for the accumulation of the necessary amount of the ingested wood, we are ignorant of the length of time the borings remain in the caecum before being ejected to the outside, and a great deal of the material thus secured might represent only the earliest stage of the digestive process; further, there is the possibility that some digestion takes place after the wood leaves the caecum, during its passage through the rather long intestine, especially the enlarged proximal portion, which contains a typhlosole. It seems extremely desirable that the material analyzed should be secured *after it has passed entirely through the digestive tract in normal fashion,* and been ejected through the excurrent siphon.

EXPERIMENTAL

At the marine laboratory maintained by the San Francisco Bay Marine Piling Committee on the Oakland mole of the Southern Pacific Railroad, through whose coöperation these studies have been made possible, for more than a year the writers have had under observation in aquaria a considerable number of *Teredo navalis,* which highly destructive species occurs locally in great numbers (Kofoid, 1921; Kofoid and Miller, 1922). The animals have continued boring and appear to thrive under conditions of aquarium life. From time to time wood borings were ejected in considerable quantities from the siphons (pl. 18, fig. 2). Such borings were carefully collected with a long pipette and dried. In about eight months sufficient material was accumulated by this method to permit of successful analysis.

Two aquaria, which we will term No. 1 and No. 2, supplied all the wood particles used. The original wood in both cases was Douglas fir, consisting in No. 1 of squared blocks planted in the bay for experimental infection and later placed in the aquarium, and in No. 2 of a section of piling infected at the time it was pulled. The material from the two aquaria has been kept separate and subjected to parallel analyses, as below described, thus rendering the results doubly significant.

The possibility was recognized of changes occurring in the composition of the wood subsequent to ejection, especially as it was not always possible to collect the borings with desirable promptness. In order to test the probability of such changes, some of the borings (series 1, sample 2) were allowed to remain on the bottom of the aquarium for about six months before being pipetted off.

The borings as collected were dried overnight at 100° C. in an electric oven, and crushed to pass a wire sieve having 50 meshes to the linear inch. Samples of the original wood were reduced to sawdust, then ground to pass through the 50-mesh sieve. To avoid changes in moisture content, all samples were preserved for analysis in tightly fitting glass stoppered bottles.

METHODS OF ANALYSIS

Analyses were made for moisture, ash, calcium, nitrogen, benzene extract, alcohol extract, reducing sugars in alcohol extract, hemicelluloses, cellulose, lignin, and furfural yield on distillation with hydrochloric acid. All these determinations were made on one sample of wood and the corresponding sample of ejected borings. On subsequent samples some of the determinations were omitted. Whenever possible determinations were made in duplicate, but in some instances the limited amount of available material made it necessary to depend upon single determinations.

1. *Moisture.*—One gram was dried for seventeen hours at 100° C. in a constant temperature electric oven.

2. *Ash.*—The dried material from the moisture determination was transferred to a platinum dish and incinerated over a wire gauze at a temperature below redness.

3. *Calcium.*—The ash was digested in dilute hydrochloric acid and the dissolved calcium estimated by precipitation as oxalate in slightly acid solution, and titration of the precipitate with permanganate. The conditions of precipitation were essentially those of McCrudden (1909).

4. *Nitrogen.*—Seven-tenths gram of material was treated by Gunning's modification of the Kjeldahl method. The results were calculated as protein by multiplying the nitrogen value by the factor 6.25.

5. *Benzene extract.*—One gram of the material was weighed out into an alundum extraction thimble and dried at 100° C. for several hours, then extracted for six hours in a Soxhlet apparatus. The benzene was evaporated off and the residue dried at 100° C. and weighed.

6. *Alcohol extract.*—The residue remaining in the thimble after the benzene extraction was extracted with 95 per cent alcohol for six

hours, the alcohol evaporated off and the residual extract dried at 100° C. and weighed.

7. *Reducing sugars in alcohol extract.*—The alcohol extract was digested in about 25 c.c. of hot water, allowed to cool, and basic lead acetate solution added until no further precipitation occurred. The precipitate was filtered off and the clear solution deleaded with sodium carbonate and filtered. The filtrate was neutralized with acetic acid, made up to 100 c.c. and reducing sugars determined by the Munson and Walker (1906) method, the cuprous oxide being burned to cupric oxide and weighed as such in the manner recommended by Davis and Daish (1913).

8. *Hemicelluloses.*—After the alcoholic extraction, the contents of the thimble were transferred to a 300 c.c. Erlenmeyer flask and hydrolyzed by digesting on the steam bath for three hours with 1 per cent hydrochloric acid, the conditions being those proposed by Spoehr (1919). The undissolved residue was filtered off and used for the cellulose and lignin determinations. The filtrate containing the hydrolyzed carbohydrates was neutralized with solid lead carbonate and after removing the lead precipitate and deleading, the reducing sugars were determined as described under "reducing sugars in alcohol extract."

Cellulose and lignin were determined upon separate portions of the residue remaining after the acid digestion for the removal of hemicelluloses.

9. *Cellulose.*—One portion of the residual material from the hemicellulose determination was transferred to a weighed Gooch crucible carrying a filtered disk of mercerized cotton cloth. Cellulose was then determined by the chlorination method of Sieber and Walter, which has been previously described by one of us (Dore, 1920*a*).

When this method was applied to the ejected borings, it gave a cellulose residue contaminated with a certain amount of non-cellulose material that resisted chlorination. To correct for the presence of this extraneous matter, the crude cellulose residue was weighed and the cellulose dissolved out of the mixture by digesting overnight in cold 72 per cent sulfuric acid. The mixture was diluted with water. The undissolved non-cellulose residue was collected on the original filter, washed, dried, and weighed. Its weight was deducted from the weight of crude cellulose previously obtained, thus giving the weight of true cellulose.

10. *Lignin.*—Another portion of the residual material from the hemicellulose determination was transferred to a 300 c.c. Erlenmeyer

flask, 10 c.c. of 72 per cent sulfuric acid added, and the whole allowed to stand overnight. The mixture was then diluted with 150 c.c. of water, heated to boiling and filtered on a Gooch crucible provided with a filtering disk of mercerized cotton cloth. The residue was washed thoroughly with hot water, dried in a glass stoppered weighing bottle for seventeen hours at 100° C. and weighed as lignin.

In order to learn whether the material obtained from the borings was actually lignin, it was submitted to alternate treatments with chlorine and 3 per cent sodium sulfite solution. The characteristic color reactions of lignin with chlorine and sulfite solution were given. The treatments were repeated until the sulfite solution was nearly colorless. Practically no residue then remained, indicating that the analytical product probably consisted entirely of lignin.

11. *Furfural yield on distillation with hydrochloric acid.*—One gram of the original material was treated by the method for pentosans described by the Association of Official Agricultural Chemists (1912).

Results

In tables 1 and 2 below are given the results of the analyses of wood and borings by these methods.

TABLE 1

Analyses of Wood and Borings. Series I

As found. All figures in percentages of air-dried material

Determination	Original Wood			Borings Sample 1			Borings Sample 2		
	Individual		Average	Individual		Average	Individual		Average
Moisture	4.89	4.91	4.90	7.36	...	7.36	7.31	...	7.31
Ash	8.42	8.02	8.22	24.17	...	24.17	30.66	...	30.66
Calcium in ash	0.62	0.68	0.65	0.66	...	0.66	...	...	...
Nitrogen	0.08	0.08	0.08	0.38	...	0.38	0.74	...	0.74
Protein (N×6.25)	...	...	0.50	...	...	2.27	...	...	4.62
Benzene extract	0.37 0.37	0.38 0.35	0.37	0.36 0.34	0.25	0.32	0.48	0.39	0.44
Alcohol extract	7.96 8.00	7.90 7.13	7.75	27.09 27.03	25.60	26.57*	...	...	...
Sugars in alcohol extract	0.33 0.44	0.32 0.32	0.35	0.09	0.15	0.12	...	...	...
Hemicelluloses (as dextrose)	(4.20)† 5.04	5.32 5.24	5.20	4.24	4.32	4.28	5.08	5.64	5.36
Cellulose	47.08	47.52	47.30	14.79	13.04	13.91	11.54	...	11.54
Lignin	26.47	26.41	26.44	36.11	...	36.11	32.13	...	32.13
Furfural yield	4.75	4.53	4.64	3.91	...	3.91	3.38	...	3.38

* Contains much NaCl. † Excluded from average.

TABLE 2

ANALYSES OF WOOD AND BORINGS. SERIES II

As found. All figures in percentages of air-dried material

Determination	Original Wood			Borings		
	Individual		Average	Individual		Average
Moisture	8.47	8.65	8.56	7.49	7.15	7.32
Ash	6.90	7.08	6.99	18.83	18.87	18.85
Nitrogen	0.14	...	0.14	0.70	0.72	0.71
Protein (N × 6.25)	0.87	...	0.87	4.38	4.50	4.44
Benzene extract	0.46	0.39		0.40	0.42	
	0.39	0.36	0.40	0.38	0.47	0.42
Sugars in alcohol extract	nil	nil	nil	nil	nil	nil
Hemicelluloses	11.08	12.64				
(as dextrose)	11.76	12.08	11.87	8.44	8.48	8.46
Cellulose	39.44	39.87	39.66	14.12	15.79	14.95
Lignin	23.63	22.91	23.27	38.16	37.71	37.93
Furfural yield	4.93	...	4.93	5.80	...	5 80

The purpose in determining moisture, ash, and protein was to enable us to reduce all data to a comparable basis. Since normal wood contains but small amounts of ash and protein, the amount found of these constituents may be taken as an approximate measure of the non-woody substances present in the samples. Accordingly, ash represents chiefly mineral contamination (shell fragments, salt, etc.) while protein represents animal remains.

The analytical figures for the respective wood samples and their corresponding borings are not directly comparable with one another since they are mixed with different amounts of non-woody material. In order to bring them to a common basis, the data have been recalculated to a moisture-free, ash-free, and protein-free basis. The results are given in table 3.

TABLE 3

RECALCULATION OF DATA OF TABLES 1 AND 2

	SERIES I			SERIES II	
		Borings			
-	Wood	(1)	(2)	Wood	Borings
Moisture—plus ash, plus protein	13.62	33.80	42.59	16.42	30.61
Moisture-free, ash-free and protein-free material	86.38	66.20	57.41	83.58	69.39
DATA RECALCULATED TO MOISTURE-FREE, ASH-FREE, AND PROTEIN-FREE BASIS					
Hemicelluloses	6.02	6.46	9.33	14.23	12.19
Cellulose	54.74	21.01	20.10	47.45	21.54
Lignin	30.60	54.55	55.97	27.84	54.66
Furfural yield	5.37	5.91	5.89	5.90	8.36

The figures for benzene extract and alcohol extract appear to have no special significance. The former represents resinous matter, the latter tannins, coloring matter, and soluble sugars. None of these except the soluble sugars can be regarded as having any nutritive value for animals. The analyses show that extremely small amounts of soluble sugars are present in wood and borings. Accordingly, neither benzene soluble nor alcohol soluble constituents have been considered in the recalculations.

DISCUSSION OF RESULTS

The data show that each of the samples of ejected matter contains a much lower percentage of cellulose and a much higher percentage of lignin than the wood from which it was derived. The figures for hemicelluloses and furfural yield are less regular and not readily comparable on the basis given.

Inasmuch as it is extremely unlikely that any lignin was synthesized during the passage of material through the digestive tract of the animal, the increase in lignin is to be ascribed to concentration by removal of cellulose and other wood constituents. Assuming that the absolute amount of lignin remaining in the residue is the same as was in the original wood, we may calculate the percentage of the original wood substance remaining in each of the three samples of borings by determining in each case the ratio of the lignin content to that of the original wood. Thus the percentages of original wood substances in the samples of borings are:

$$\text{Series I, sample 1}\quad \frac{30\ 60}{54\ 55} \times 100\% = 56\ 1\%$$

$$\text{Series I, sample 2}\quad \frac{30\ 60}{55\ 97} \times 100\% = 54\ 7\%$$

$$\text{Series II,}\quad \frac{27\ 84}{54.66} \times 100\% = 50\ 9\%$$

The data of table 3 have been recalculated so that the constituents of the borings are expressed, not on 100 parts of borings, but on 100 parts of original wood, or, in other words, upon the number of parts of borings corresponding to the percentages found in the preceding paragraph. The results are given in table 4.

TABLE 4

DATA OF TABLE 3 CALCULATED TO PERCENTAGES OF ORIGINAL WOOD

Determination	SERIES I			SERIES II	
	Woods Parts per 100	Borings (1) Parts per 56.1	Borings (2) Parts per 54.7	Wood Parts per 100	Borings Parts per 50.9
Hemicelluloses	6.02	3.62	5.10	14.23	6.20
Cellulose	54.74	11.79	10.99	47.45	10.96
Lignin	30.60	30.60	30.60	27.84	27.84
Furfural yield	5.37	3.32	3.22	5.90	4.26

On this basis, it appears that during its passage through the animal's digestive tract the wood has lost about 80 per cent of its cellulose, and from 15 to 56 per cent of its hemicelluloses, including from 11 to 40 per cent of its furfural yielding constituents such as pentosans, etc.

The simplest explanation of this disappearance of carbohydrate material is that the cellulose and hemicelluloses of wood are partly digested by the teredo and probably hydrolyzed to simple carbohydrates which the animal can use as food. This view is consistent with Harrington's (1921) suggestion that the teredo contains enzymes capable of hydrolyzing cellulose; also with the results of Billard (1914), Bierry (1914), and Bierry and Giaja (1912), who have found cellulose-splitting enzymes in other mollusks.

The cellulose content and lignin content of the three samples of borings are remarkably uniform (see table 3). This would seem to indicate the composition of the residue which the teredo is incapable of digesting.

The experimental data rest upon the assumption that the analytical products, cellulose and lignin, are true to name. The results for the wood are based on well established methods (Dore, 1919, 1920) and may be accepted without question. In the case of the ejected matter, which is somewhat contaminated with animal remains, there might be some doubt as to whether the product after solution in 72 per cent sulfuric acid is actually lignin and whether the loss in weight which the chlorinated residue underwent really represents cellulose.

In order to determine the possibility of animal matter remaining undissolved by 72 per cent sulfuric acid and contaminating the lignin, the following experiment was performed: Several teredos were taken from the wood and the caeca dissected out and rejected, in order to eliminate the wood particles they contained. The flesh, thus freed from woody matter, was then dried and pulverized. The residue was digested overnight in cold 72 per cent sulfuric acid and then diluted in the same manner as in carrying out the lignin determination. Solution of the material was practically complete, showing that the presence of animal remains in the residue does not interfere with the lignin determination.

In the case of the cellulose, considerable difficulty was experienced in filtering and washing the material after the second chlorination. This appeared to be due to the presence of colloidal material in the mass. On dissolving out the cellulose from this residue by 72 per cent sulfuric acid, considerable amounts of insoluble substance were obtained, as shown by table 5.

TABLE 5

CELLULOSE CONTENT OF WOOD AND BORINGS

(Expressed in grams obtained from 1 gram of original material)

	SERIES I 1st sample of borings		SERIES I 2d sample of borings	SERIES II Sample of borings	
	(1)	(2)		(1)	(2)
Residue after chlorination	0.2620	0.2661	0.1420	0.2677	0.2714
Residue after acid digestion	0.1141	0.1357	0.0266	0.1265	0.1135
Cellulose by difference	0.1479	0.1304	0.1154	0.1412	0.1579

It is not believed that the insoluble residue contained a great deal of animal matter, as such material appears to be largely soluble in 72 per cent acid under the conditions employed. The residue is considered as consisting largely of lignin which escaped chlorination, due partly to the protective action of the colloidal mass and partly to the fact that the chlorination was not continued as long as usual on account of mechanical difficulties.

It is to be noted that the second sample of borings in Series I contains considerably more protein than the first sample of borings of the same series (see table 1). Nevertheless, it gave a much smaller yield of insoluble material in the cellulose determination, and the figures for cellulose and lignin were very similar to those from the other samples. This would tend to indicate that the methods used for cellulose and lignin are not affected by the amount of animal débris present in the sample.

It can be shown that, even if the analytical methods are seriously defective, the greatest possible allowance for contamination of products does not invalidate the general conclusion that the borings contain a considerably smaller proportion of cellulose to lignin than the wood from which they were derived. If the cellulose figure is low, the correct value can in no case be higher than the total residue after chlorination (see table 5) and if the lignin is high, due to contamination with animal remains, the correct value can in no case be lower than the lignin value given minus the total protein of the sample. From tables 1, 2, and 5 we can then calculate the following:

	Series I Borings		Series II Borings
	(1)	(2)	
Maximum possible value for cellulose	26.40	14.20	26.95
Minimum possible value for lignin	33.84	27.51	33.49

In every case, the cellulose is materially less than the lignin, whereas in the original wood the cellulose is about twice as much. It appears impossible, therefore, to draw from the data any other conclusion than that the cellulose partly disappears during digestion.

We have previously referred to the possibility that the change in the composition of the wood may occur after the material is ejected by the borer. The compositions of the first and second samples of borings in Series I furnish some experimental evidence on this point. Although the second sample was purposely left in the sea water for at least six months longer than the first, there was no significant reduction in carbohydrate constituents (see table 3). In view of the extreme resistance of wood to purely chemical action, and the absence of known cellulose-destroying fungi or bacteria in sea water, it seems more reasonable to ascribe the loss of cellulose and other carbohydrates to digestive action while in the body than to external agencies.

Plankton is doubtless the principal food of *Teredo* as of other lamellibranchs, and on account of its high protein content is probably very suitable for purposes of growth and repair of waste. The teredo which is boring, and consequently growing to fill the larger cavity, requires, besides the protein food to provide for growth, a considerable additional amount of food to furnish energy for its boring activities. This energy could be supplied by the protein material of the plankton, but much more efficiently by carbohydrates, inasmuch as these last are completely oxidized and there is therefore no necessity of getting rid of nitrogenous products. If, then, when its boring activities are greatest, the teredo has available a considerable supply of carbohydrate material to furnish the necessary energy and that available in proportion to the amount of work to be done, it appears to be a most natural arrangement, admirably adapted to its needs. The carbohydrates of the wood therefore play an important part in supplying the teredo with energy when it is most needed.

It does not appear probable that *Teredo* could subsist over any long period upon the wood alone, because of the negligibly small amount of protein material. Especially during boring would considerable nitrogenous matter be required. The need for a simultaneous supply of plankton is accordingly indicated.

If the conclusion is accepted that wood tissue is partly digested and absorbed as food by *Teredo,* some light is thrown upon the probable mechanism by which toxic substances injected into the timbers of marine structures protect against teredo attack. If partial digestion of wood occurs, it is clear that all substances contained in the wood must experience an intimate contact with the teredo's digestive fluids over a considerable period of time. Optimum conditions then prevail for the absorption of toxic substances and their effectiveness is limited only by such factors as lack of solubility, inability of their solutions to penetrate the walls of the digestive tract, etc., these factors being dependent upon the properties of the agent and not upon the condition of exposure. No case of failure of a given toxin to protect can be ascribed to physical isolation of the borings as we might expect if the wood were regarded as wholly undigested and merely mechanically handled by the teredo.

These considerations offer practical suggestions in regard to (1) the commercial preservative treatment of marine timbers, and (2) the testing of the toxicity of preservative substances. We may conclude that the established practice of preserving marine timbers by impregnating the wood with toxic substances is a rational and efficient process for introducing these substances into the animal's system, for it is clear that the teredo cannot bore into the wood without being exposed to the action of any toxins that are capable of entering through its digestive tract. As to methods of carrying out toxicity tests, it would appear that those methods which use the wood as a vehicle for carrying the toxin possess a distinct advantage over methods in which the toxin is introduced into the animal by some other means, on account of the greater certainty that contact with the digestive juices will occur.

In conclusion, the authors wish to acknowledge, and express their thanks for, helpful suggestions which they have received from

members of the Advisory Committee appointed by the University of California to coöperate with the San Francisco Bay Marine Piling Committee.

SUMMARY

1. It has long been a debatable question whether or not the boring mollusks of the genus *Teredo* exercise any digestive action on the wood particles which are swallowed during boring and retained for a time in the caecum before being passed to the outside. The absence of any conclusive evidence has suggested an experimental approach to the problem.
2. A chemical analysis has been made of three samples of wood borings ejected by *Teredo* and of two samples of the original wood from which the borings were derived.
3. The results indicate that the wood loses about 80 per cent of its cellulose and 15 to 56 per cent of its hemicelluloses during its passage through the digestive tract of *Teredo.*
4. The carbohydrates which disappear are probably utilized as food by *Teredo.*
5. The woody portions of the ejected material have a uniform composition of about 21 per cent cellulose and 55 per cent lignin. Possibly this represents the ultimate residue which the animal is unable to digest.
6. The digestible carbohydrates in the wood may play an important rôle in the economy of *Teredo* in supplying energy for its boring activities, supplementing the plankton diet upon which it mainly depends for growth and repair.
7. Digestion of wood constituents by *Teredo* produces optimum conditions for the absorption of toxic substances contained in the wood.
8. Impregnation of wood is an efficient method of introducing toxins into the borer's system, either for commercial preservation of the wood or for testing experimentally the protective action of toxins, because of the assured contact between toxin and digestive fluids.

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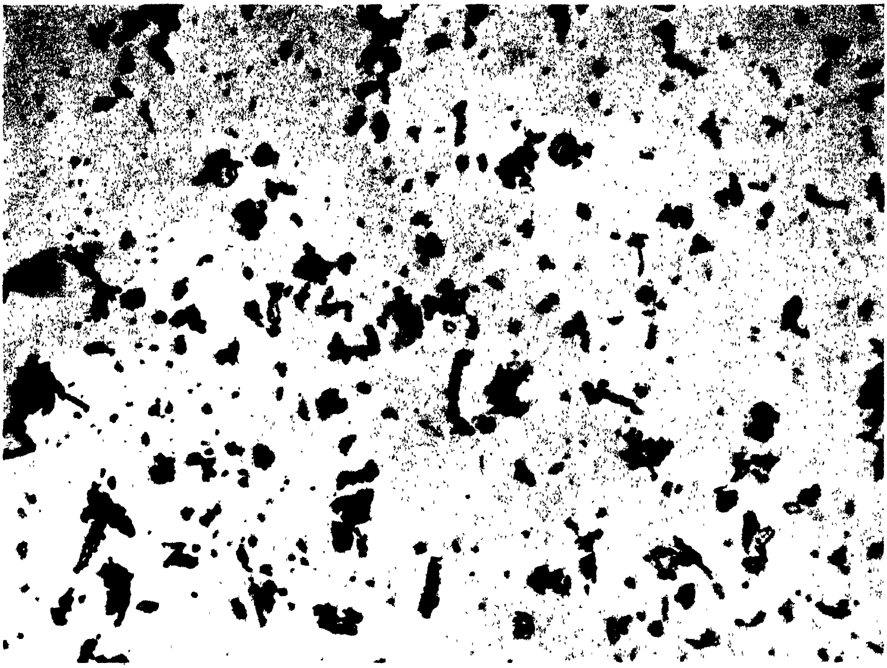
EXPLANATION OF PLATE

PLATE 18

Fig. 1. Wood borings ejected by *Teredo,* magnified 300 diameters. Observe that in many of the particles the cell walls are visible.

Fig. 2. Siphons protruding from blocks of wood containing *Teredo.* Photographed in aquarium, natural size. The long siphons are the incurrent ones. The excurrent siphons are relatively short, usually protruding only two or three millimeters from the openings of the burrows. Note ejected wood borings around many of the openings.



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VARIATIONS IN THE PALLETS OF TEREDO NAVALIS IN SAN FRANCISCO BAY

BY

ROBERT CUNNINGHAM MILLER

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INTRODUCTION

During the course of the study of variations in the shell of *Teredo navalis* in San Francisco Bay (Miller, 1922), an investigation was made as well of variations occurring in the pallets of this species. The results of this investigation were for several reasons not incorporated in the published results of the earlier study. As every collector of this group of mollusks is aware, it is extremely difficult to secure good series of pallets which have not been damaged by accident or erosion to such an extent as to render them unsuitable for a study of physiological variation. In the rather limited number of normal and well preserved pallets available in our collections, it was found that the index of individual variation was extremely high. The types of variation observed were not at all so definitely correlated with ecological conditions as is the case with shells. Finally, variations in the pallets, although very striking as matters of observation, are not of such a nature as to lend themselves to statistical treatment. For these reasons it did not seem pertinent to include remarks on the pallets in our discussion of variations in the shell.

After the earlier paper had gone to press, however, there came to hand Bartsch's recent (1922) monograph of American shipworms, in which certain minor differences in the pallets of *Teredo* are regarded as being of considerable systematic importance. One species, indeed (*Teredo beaufortana*), is offered for acceptance on the basis of pallets alone, the shell having not yet been discovered; and in several other instances slight deviations in the pallets are emphasized to such a degree as to constitute what seems to be, to say the least, an impracticable precedent. It is perhaps desirable, therefore, to set forth at this time such data as we have on variation in the pallets of *Teredo navalis* in San Francisco Bay, because of their bearing on the systematic treatment of the entire *Teredo* group.

DESCRIPTION OF THE PALLETS

The pallets of Teredinidae are peculiar structures, characteristic of this family of boring mollusks. In *Teredo navalis* they are small, spatulate objects, consisting of a relatively broad blade, flattened on the inner surface, somewhat convex on the outer, into the base of which is inserted a typically narrow, cylindrical stalk. The stalk is calcareous and rigid. The blade also has its proximal portion calcified, but ends in a darker colored chitinous tip, which is more or less deeply excavated.

The pallets are attached at the posterior end of the animal, on each side of the siphons, being inserted beneath a muscular collar, which covers the stalk and partly conceals the blade when the structures are retracted (pl. 19, fig. 1). Ordinarily the siphons are protruded from the opening of the burrow for purposes of feeding and respiration; but if the animals are disturbed, or environmental conditions become unfavorable, the siphons are immediately withdrawn and the pallets are thrust into the opening to act as a plug (pl. 19, fig. 2), thus effectually keeping out intruders and affording protection for a considerable period of time from reduced salinities or other unfavorable conditions. The chitinous tips of the pallets, which are slightly flexible, doubtless permit of a more efficient closing of the burrow than would be the case if the entire structure were rigidly calcified.

In the early stages of the teredo's life in the wood, the nacreous lining of the burrow is partly visible at the surface, giving the appearance of a carefully sculptured doorway, with definite grooves dorsad and ventrad for the passage of the two siphons (pl. 19, fig. 2). With increasing age, however, this exposed part of the lining of the burrow becomes eroded or dissolved away; the posterior end of the animal is gradually withdrawn, the larger size of the pallets enabling them to close the tapering burrow without extending to the surface of the wood. Thus, in an older specimen, when the siphons are retracted, the only indication of its presence is an inconspicuous opening, as seen immediately to the right of the principal figure, plate 19, figure 2. The siphonal end of the animal, however, is never withdrawn in this way more than a few millimeters from the surface of the wood; and the nacreous lining is normally kept in good repair, forming a sheath into which the pallets may tightly fit when extended.

GROWTH CHANGES

We find, as we should expect of structures so useful in the economy of the animal, that the pallets are formed very early in the boring life. The larval teredo has hardly initiated boring activities when rudimentary pallets come into evidence, and these become functional when the animal is only one or two millimeters in length. In these early pallets the blade is short and broad, and the stalk relatively long. But by the time the animal has reached an age of one month the pallets have assumed normal proportions, and, so far as our observations go, no changes ensue thereafter as a result of growth alone.

A small series of pallets selected for age is shown in plate 19, figure 4. The factor of individual variation could not be entirely eliminated even in this limited group; but it is rather evident that such changes as occur after the first month are due primarily to effects of wear and a gradual darkening of the chitinous tip, which generally becomes more pronounced in the older pallets. Indeed, the pallet estimated to be one month old more nearly approaches what we consider the type of *navalis* than do the others in this series.

In the selection of our material to illustrate variation, pallets adjudged to be less than one month old were eliminated, in order to avoid the error of including as variates specimens which might not yet have reached their normal proportions.

The age of pallets was estimated by counting the ridges on the corresponding shells, as explained in our earlier paper (1922, pp. 296 ff.).

NATURE AND CAUSES OF VARIATIONS IN THE PALLETS

We have figured, in plate 20, series of pallets from three localities in San Francisco Bay, namely, Crockett, Dumbarton and Goat Island. For the location of these stations and a discussion of the ecological conditions characteristic of each one, the reader is referred to our earlier paper (1922, pp. 301 ff.).

In each of the series in question, the pallet at the extreme left of the illustration is regarded as approaching the type of *navalis*, as figured by Jeffreys (1869) in volume 5 of the British Conchology (pl. liv, fig. 2). The other specimens in the series represent departures in greater or less degree from the type. The smaller size of the Dumbarton material is not regarded as significant; our specimens from this locality were secured from timbers exposed only a few months, whereas specimens from the other two localities were taken when older.

In studying variation in the pallets, it is important that physiological factors should be separated so far as possible from purely physical ones. Of the latter there are those already mentioned of accident and erosion. The pallets are, from the nature of their function, much exposed to unfavorable circumstances. In times of stress they form the barrier against undesirable and often lethal conditions. They are much subject to wear from being frequently thrust into the constricted end of the burrow. While in such position they may be eroded by organic acids present in the water or the wood. If a foreign object, a piece of floating driftwood, for example, comes violently into contact with the surface of a timber in which teredos occur, the pallets are likely to be broken.

In plate 19, figure 4, it will be seen that even a pallet four months old may show very decidedly the effects of wear. In figure 5 of this plate we have compared a normal and rather typical pallet from Goat Island with an older pallet from the same locality which illustrates the maximal effect of age and erosion, the original form of the distal portion of the blade being entirely lost. The secondary calcareous accretions about the stalk may be pathological; similar accretions have been noted in other cases, as in plate 20, figure 6 *g*, but are infrequent.

The pallets may also be secondarily modified by the nature of the burrow. If the course of the burrow deviates suddenly near the opening, the pallets will tend to be asymmetrical, with the stalk curved and inserted at one side of the median line, as in figure 6 *c*, plate 20. If the burrow be straight for some little distance from the surface, expanding gradually and regularly, the pallets will usually be well formed, elongate, and tapering (pl. 20, fig. 7 *b*). If the burrow expands suddenly, owing to an unusually rapid growth of the animal, or if the opening becomes enlarged, as may easily occur in soft wood, the pallets are likely to be broad and blunt in appearance (pl. 20, fig. 8 *e*). In other words, if they are to perform their function aright, *the pallets must fit the burrow;* hence they will be influenced by the factors determining the nature of the latter, such as rapidity of the growth of the borer, hardness of the wood penetrated, and the degree of crowding, which often determines the course of the burrow.

Excluding the foregoing factors, which may be spoken of as *adventitious,* we find yet a number of variations which we may term *physiological,* in that they are indirectly rather than directly produced. These may be separated into two types, which for convenience we shall term *individual* and *environmental*, the former considered to be produced by obscure causes bound up in the physiology of the individual organism, the latter affording some evidence of correlation with conditions of the environment.

As an illustration of individual variation, we would call attention to differences which frequently appear between two pallets of the same pair. Examples of this are shown in plate 19, figure 3. The differences between the members of each of the three pairs of pallets figured are so marked that they would not have been suspected of belonging to the same pair, had we not actually removed them from the animals. Variations of this sort cannot of course be attributed to factors in the environment (exclusive of those of an adventitious nature), which would be expected to operate alike on the two members of each pair; rather do they represent some unknown factor of the biochemical or other aspect of the organization of the animal which tends to asymmetry.

We have found in our study of pallets that the range of this type of variation is so great as to render it extremely difficult to recognize variations resulting from ecological factors. It has been noted, however, that pallets from the upper bay tend to have a heavier periostracum than those from the middle and lower bay, which corresponds with our observation concerning the periostracum of the shell (1922, pp. 311, 312), which was found to be thicker and rougher in the case of specimens from the upper bay. It may be stated also, as a fact of general observation, that the chitinous tips of the pallets tend to be darker in color in specimens from the upper bay than in those taken elsewhere. This is not always true in individual cases, as will be seen by reference to plate 20; the tips of pallets 8 *b*, 8 *d*, and 8 *g* in the Goat Island series are almost as dark as the darkest of the Crockett pallets (fig. 6 *g*); but the proportion of pallets with a notably dark distal portion is greater among the pallets from the upper bay.

It should be mentioned in this connection, however, that pallets taken near the mud line of a pile, or from waters containing much decaying organic matter, are likely to be much stained, as was observed in the shells (1922, p. 313). It is necessary therefore to be cautious in interpreting such data.

DISCUSSION AND CONCLUSION

In the light of the foregoing data, it becomes pertinent to inquire in how far deviations in the pallets are to be regarded as of systematic importance. It is obvious, in view of the range of variation above pointed out, that if minor differences in these structures are to be looked on as specific characters, the describing of new species of *Teredo* can be limited only by the persistence of the investigator and his supply of paper and ink.

The pallets of *Teredo novangliae,* according to Bartsch (1922, p. 20), "expand suddenly beyond the stalk, forming a decidedly concave outline," while in *navalis* "they expand only gradually, forming an almost straight line." It is interesting to note that from one locality in San Francisco Bay we have pallets which expand both gradually and suddenly, with several degrees between, the proximal outlines of the blade being straight (pl. 20, fig. 6 *a*), concave (figs. 6 *c* and 6 *d*), and even decidedly convex (fig. 6 *h*; fig. 8 *f*). A similar range may be pointed out in the series from Dumbarton and Goat Island. It is still further disturbing to find a hybrid form nearly straight on one side and concave on the other, as the pallet shown in figure 6 *b*, plate 20.

Concerning *Teredo morsei* Bartsch, we learn that "the pallets are rather broad at the anterior termination of the calcareous portion. The corneous portion is rather short and deeply cut. The sides of the calcareous portion slope gently toward the somewhat curved and twisted stalk" (*idem,* p. 21). No figures of this species are given, but we venture to suggest that the description just quoted applies admirably to the last shell in our Dumbarton series (pl. 20, fig. 7 *h*).

The pallets of *Teredo beaufortana* are "much narrower and more elongate" than "true *Teredo navalis*" (*ibid.,* p. 22), this being apparently the only character by which the two species may be distinguished. It is interesting to note the degree to which the pallets figured for *beaufortana* approach the third pallet figured in our series from Oakland harbor (pl. 19, fig. 4).

It is rather remarkable that a specimen figured from Crockett (pl. 20, fig. 6 *a*) should so nearly approach the type of *navalis* as figured by Jeffreys (*loc. cit.*) and by Bartsch (1922, pl. 32, fig. 2), when we consider that the locality in question is the type locality of

Teredo beachi (*ibid.*, p. 19). We feel compelled to state further that during three years' intensive collecting in San Pablo Bay and the vicinity of Mare Island and Carquinez Strait by Kofoid and the writer, we have not seen any pallets which very closely approach the type of *beachi* as figured (*ibid.*, pl. 32, fig. 4), although this is asserted by Bartsch (1921, p. 22) to be the form causing the extensive damage in this region. We have likewise sought in vain for pallets of the form in question in material collected from the Mare Island dikes in 1914 by Barrows. We are forced to believe that the pallet figured for this form has been either very badly drawn, or drawn from an extremely aberrant specimen. Whatever be the original of this figure, it is certainly not *typical* of anything occurring in the San Francisco Bay region.

It should be noted in this connection that the material identified for Barrows by Bartsch as *Teredo diegensis* was taken from the type locality of *beachi,* and hence could not have been *townsendi,* as stated by Bartsch (1922, p. 27). The latter form occurs at only one locality in San Francisco Bay, namely South San Francisco (Kofoid, 1921, p. 35), where Bartsch's specimens were collected by Townsend, who was for a time employed by the San Francisco Bay Marine Piling Committee. It has never as yet been found in the brackish waters into which *T. navalis* extends its range in San Francisco Bay.

It would appear, then, that, unless their validity can be established on other grounds than the form of the pallets, the proposed species *beachi, novangliae, morsei,* and *beaufortana* are in a somewhat precarious position. The status of *beachi* as determined by the shell we have treated in an earlier paper (1922, pp. 313 ff.). The shell of *novangliae* is chiefly distinguished (Bartsch, 1922, p. 20) by the size of the auricle and the roughness of the median area, characters which we have shown (1922, pp. 309, 311) to be extremely variable. The distinctive character of *morsei* (Bartsch, 1922, p. 22) is "in having the ridges of the anterior area more numerous and much more closely spaced"; these characters we have shown (1922, pp. 306 ff.) to be matters of age and environment. *Teredo beaufortana* we fear will have to await general recognition until its shells are brought to light.

There is no reason to believe that variation in *Teredo navalis* is a phenomenon limited to San Francisco Bay. Rather is it a biological factor to be reckoned with wherever the distribution of this species extends. Such being the case, we would urge extreme caution in the recognition of new species in this group until their claims be established on the most incontrovertible evidence. This is especially desirable in view of the facility with which *Teredo navalis* invades estuarine harbors and is therefore subject to variation resulting from the amplitude of environmental conditions.

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EXPLANATION OF PLATES

PLATE 19

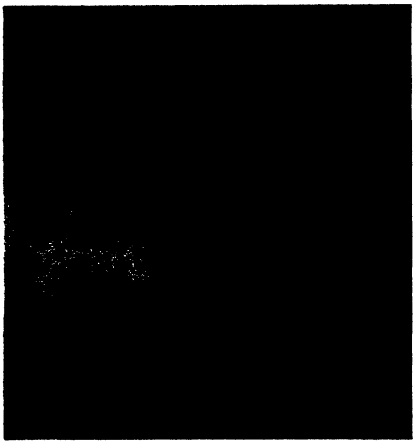
Fig. 1. Siphonal end of *Teredo navalis*, showing position of pallets. × 5.

Fig. 2. Pallets in position, closing entrance to burrow. The dark area at the right is the opening to the burrow of an older, retracted specimen. × 10.

Fig. 3. Pallets arranged in pairs, illustrating variation in two members of the same pair. × 5.

Fig. 4. Series of pallets from the Oakland Harbor Light Station, representing ages of approximately two weeks (?), one month, two months, three months, and four months, respectively.

Fig. 5. Comparison of a normal and nearly typical pallet from Goat Island with an older one from the same location, showing maximal effect of age and erosion.



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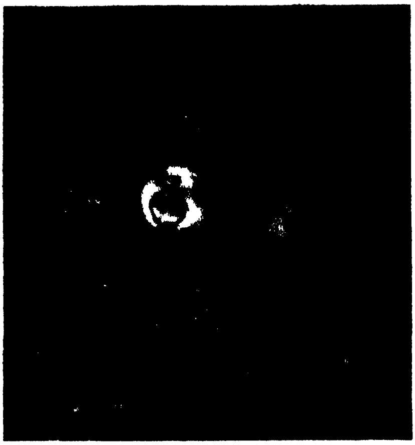

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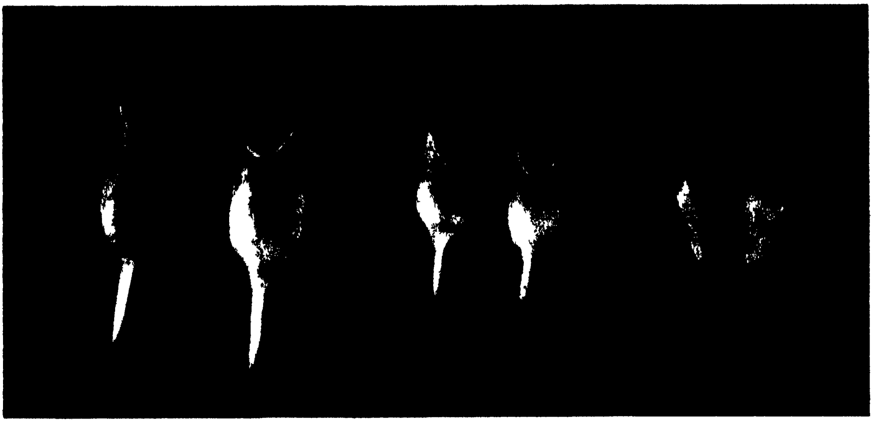

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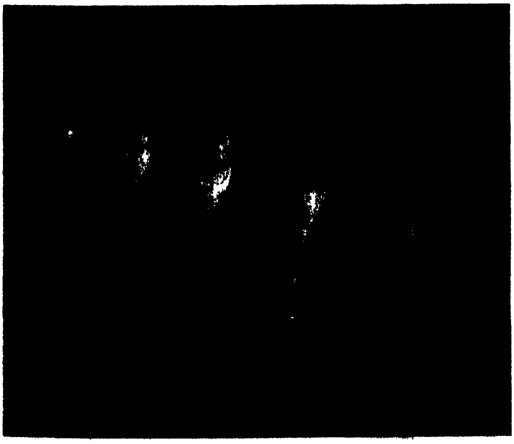

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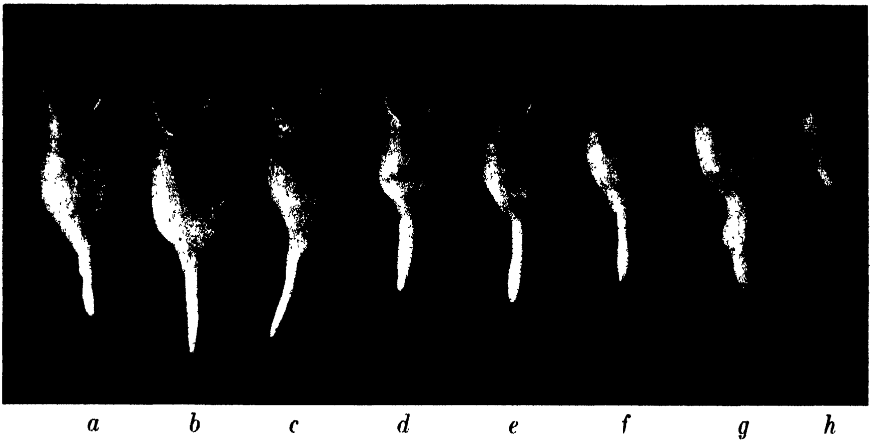
PLATE 20

Fig. 6. Series of pallets selected to illustrate variation at Crockett, San Francisco Bay.

Fig. 7. Series of pallets selected to illustrate variation at Dumbarton, San Francisco Bay.

Fig. 8. Series of pallets selected to illustrate variation at Goat Island, San Francisco Bay.



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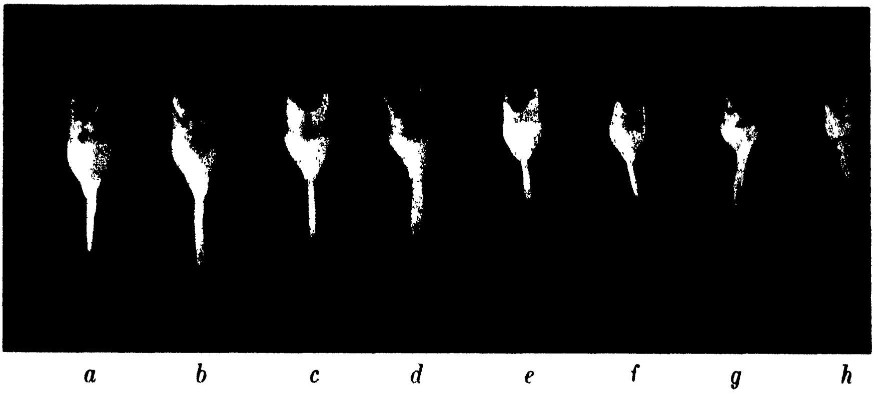

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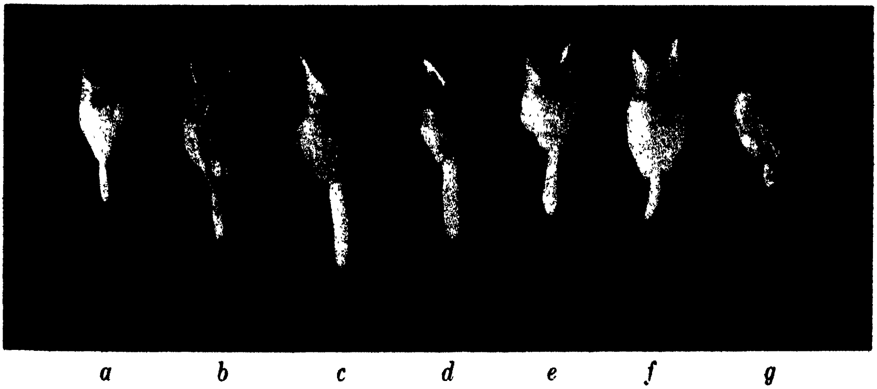

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SOME TIDE-WATER COLLECTIONS OF MARINE DIATOMS TAKEN AT HALF-HOUR INTERVALS NEAR SAN DIEGO, CALIFORNIA

BY

WINFRED E. ALLEN

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SOME TIDE-WATER COLLECTIONS OF MARINE DIATOMS TAKEN AT HALF-HOUR INTERVALS NEAR SAN DIEGO, CALIFORNIA

BY

WINFRED E. ALLEN

(Contribution from Scripps Institute for Biological Research of the University of California)

In the last two or three years the scientific staff of the Scripps Institution has been giving much attention to variations of hydrogen ion concentration (pH) in sea water and to the relationships of these variations to other phenomena, including variations in abundance of phytoplankton.

The intricacies of the oceanic complex are so profound and the difficulties of observation are so great that it has, so far, been found impossible to make very satisfactory interpretations of conditions observed. Under present limitations it is evident that adequate foundation for interpretations can be laid only at the expense of much time and energy. There is, however, the possibility that valuable indications as to the true path to reliable interpretations may be obtained through studies of less intricate complexes (e.g., small fresh-water lakes) or of special conditions involving marked differences in factorial relationships.

After much consideration it was concluded that intensive study of tide-water at the entrance to a small bay might furnish valuable indications of the type mentioned. At 9 P.M. of November 3, 1922, our chemist, Mr. E. G. Moberg, our oceanographer, Dr. G. F. McEwen, and an assistant in hydrography, Mr. T. Woodward, began a series of collections of water samples at the entrance to Mission Bay ("False Bay") about six miles north of Point Loma, the entrance to San Diego Bay. These collections were taken at intervals of thirty minutes up to 5 P.M. on November 4. At the same intervals, beginning at 9:30 P.M., twenty-five liters of water was filtered through a small net of No. 25 bolting silk and handled according to our regular method (see Allen, 1921). The present paper discusses the results of that work from the standpoint of the phytoplankton as represented by diatoms. Particular attention was given to variations in numbers throughout the twenty hours. Dinoflagellates were also studied, but they were few in numbers and showed nothing of evident importance.

Mission Bay occupies at high tide an area of nearly or about four square miles. At low tide it is reduced to channels and lagoons of less than half that extent. The deepest point at high tide is not far from the entrance according to the U. S. Coast and Geodetic Chart for 1902, which records twenty-eight feet. It is doubtful if any point so deep as that is to be found now. The mean depth at high tide is probably not more than three or four feet. The entrance is narrow and the tidal flow correspondingly rapid. For a period of six months or more preceding the time of taking these collections there had been no rain and it had probably been four months since any fresh water drained into this bay.

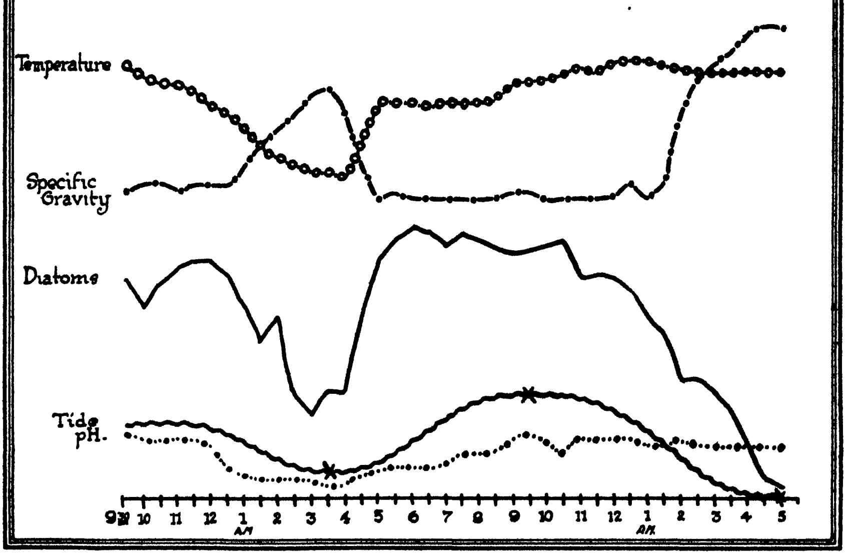

Fig. 1. Graph to show half-hourly distribution of Diatoms in tide-water at Mission Bay Bridge, Nov. 3–4, 1923

The accompanying graph (fig. 1) shows the character of the variations in successive half-hours under the five conditions investigated. Each curve is correctly drawn to scale, though the scales are not indicated in this figure. The diatom curve was plotted on semi-logarithmic paper. As shown by the tidal curve, the records begin just before high tide in the evening and run to low tide the next afternoon. The influence of the tide upon specific gravity and the number of diatoms is very conspicuous throughout the twenty hours. The influence upon temperature and pH in the night is equally evident but it is not so apparent in the daytime.

The largest number of diatoms (63,856 per liter) was recorded at 6 A.M., two hours after low water, and the smallest number (3424 per liter) was recorded at 5 P.M. at the time of low water. pH was lowest (8.32) at low tide, 4 A.M., and highest (8.40) at high tide, 9:30 P.M., (pH not corrected for salinity). Specific gravity was lowest (1.02689) at or near both high tides and highest (1.02724) at 4:30 P.M., a little before low tide. The temperature was lowest (13.6° C.) at 4:30 A.M., just after low tide and highest (15.4° C.) at 1 P.M., three hours after high tide. Tide levels ranged from six feet at 9:30 A.M. to zero at 5 P.M. Variations between the extremes mentioned may be followed by reference to figure 1.

Study of this graph makes it plain that local topography and climatic conditions have a strong influence. At night, when this influence was least, all of the other four characteristics changed with the tide. In the daytime, when the shallowness of the bay water greatly magnified the solar influence on temperature, both temperature and pH failed to respond to change in the tide. If low tide had come early in the afternoon of that day or later in the evening, it is probable that there would have been traceable change. In a larger or deeper bay, solar influence would not have been so immediate or so obvious.

Although the numbers of diatoms and the specific gravity changed with the tide throughout the twenty hours, it is notable that the change was in a direction opposite to ordinary expectation. Since most bays which have been studied in any way at all comparable to this are continuously supplied with more or less fresh water, the change of tide would serve to dilute sea water and reduce the specific gravity. Therefore samples taken at the entrance should be slightly lower in specific gravity on the ebbing tide and slightly higher on the flowing tide. In the case of this bay, the enormous surface as compared with the mass of water evidently permits such rapid concentration through evaporation that after several months without fresh-water increment there is a slight accumulation of denser water in the bay, and it is this factor that causes the condition of reversal. A similar (and consequent) explanation applies to the changes in diatoms. This explanation, however, must be taken with some caution on account of the many unevaluated factors influencing biological production and distribution. Still, it seems to be fairly certain that diatom production would be somewhat limited by the higher specific gravity and more intense sunlight of a shallow bay of this type, hindrances which were here probably augmented by higher temperatures.

The species of diatoms obtained in these collections were the typical neritic marine forms of the region. *Eucampia zoodiacus* Ehr. was the most abundant and *Chaetoceras debile* Cl. was next. There is nothing in the appearance of the catches (except the débris) to indicate that they were not taken at our pier or in some of the boat series, off shore. Such components of the plankton give, of course, still further indication that the diatom population was much more dense in the sea outside of the bay than it was in the bay at the time of making these collections.

While these samples of water and plankton were somewhat disappointing in that they yielded no positive guides to general interpretations, they have very distinct value in that they show the importance of understanding local conditions when attempting to interpret chemical, physical, or biological phenomena. They also show the risk of trying to interpret natural phenomena from meager or localized or discontinuous or inappropriate data. They derive additional value through the proof they furnish that much valuable work can be done from a location such as this on the entrance to a bay.

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PRELIMINARY STATISTICAL REPORT ON THE OCCURRENCE OF MARINE COPEPODA IN THE PLANKTON AT LA JOLLA, CALIFORNIA

BY

CALVIN O. ESTERLY

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PRELIMINARY STATISTICAL REPORT
ON THE
OCCURRENCE OF MARINE COPEPODA IN THE PLANKTON AT LA JOLLA, CALIFORNIA

BY
CALVIN O. ESTERLY

(Contribution from the Scripps Institution for Biological Research, La Jolla, California)

This paper summarizes some of the results of two years of plankton collecting from the pier at the Scripps Institution for Biological Research of the University of California at La Jolla, California. The series consists of 3471 hauls extending from September 1, 1916, through August, 1917. All hauls were made at the surface of the water, using a conical plankton net of either No. 12 or No. 9 silk bolting cloth. The mouth of the net was fourteen inches in diameter and the length of the filtering portion about thirty-four inches. In making the collections the net was tied to a cord and towed from the end of a pole held over the edge of the pier. The distance it was hauled was about 80 feet, beginning about 100 feet from the end of the pier. A wide-mouthed four-ounce bottle was tied into the peak of the net so that upon draining the net the catch was swept into the bottle.

Hauls were taken six times in twenty-four hours: at 8 A.M., noon, 4 P.M., 8 P.M., midnight, and 4 A.M. In very rough weather the collecting was omitted, and it was agreed that there need be no towing between 4 P.M. on Saturday and 8 P.M. on Sunday. Occasionally emergencies arose that prevented hauling, but on the whole the program was adhered to very well.

The author is responsible for the counting and identification of the Copepoda. The method of counting that was used throughout was, of course, one of sampling. The fluid in the bottle was decanted until a small amount, merely enough to contain the catch, remained. This residue was poured into a watch dish and the contents concentrated by shaking the dish rapidly back and forth without lifting it from the table. It is possible to gather quickly into a compact mass objects as relatively heavy as copepods. If the haul was a small one copepods of the size of *Acartia* and larger were all counted. But in most cases there were too many to permit of counting them all; so after the haul was concentrated the material was divided into two portions as nearly equal as possible, one of which was removed with a pipette. The remaining portion was shaken together again and half of it removed, if there still were too many organisms left to make fairly rapid counting possible. This procedure was repeated as often as was necessary in order to reduce the amount to be gone over to a point where enumeration would not be an unreasonable burden. In the final counting the numbers were increased in proportion to the numbers of parts into which the whole haul had been divided; that is, if the haul had been divided into eight parts, the number in the one-eighth counted was multiplied by eight to give an estimate of the total number in the haul. Before any division of the collection was made it was looked over for rare or unusual forms. Note was also taken of the relative numbers of copepods that usually occurred, and if it was apparent that one sort was abundant while another was scarce, the number of the latter was estimated upon the basis of a larger fraction of the whole (if the entire number was not counted) than was used in the case of the more numerous form.

It is fully realized that this method of counting is inaccurate so far as giving the numbers of animals actually present in a collection is concerned. That, however, was not the information most desired when the work was planned. The aim was to ascertain the *relative* numbers of different organisms under different conditions in regard to years, seasons, months, times of day, temperatures, salinities and other possible factors. Those of us who have been concerned with the project from the beginning believe that this method of enumeration is adequate to throw a good deal of light on the problem of variations in numbers of the plankton copepods; and other members of the staff concur in this view. Even when every allowance is made for errors in counting, the number of hauls and of animals taken is so large that the errors are bound to balance one another. The crudity of the method is fully understood, and the numbers of animals set down in the tables are not thought of as important except in indicating relative abundance. The method does make it possible to work fairly rapidly and with a minimum of fatigue. There is no reason to suppose that any errors that may have occurred in the counting are systematic, though the extent of any one error may be large as regards actual numbers of animals involved. If one accidental error was made, others of the same sort must have occurred many times. But accidental errors tend to become eliminated as the number of observations increases, while, in the long run, systematic errors do not disappear.

The opportunity for another possible fault in this series should be recognized, namely, the method of collecting. The towing was done by seven different men, some of whom took the night hauls while others took the day hauls. Some worked on alternate weeks for a part of the two years and others worked week after week consecutively. It need hardly be said that changes in the personnel sometimes occurred, so that new men had to work into the routine. There is no doubt that it would have been better if the collecting could have been done by the same two persons throughout the two years, but that was impossible. Perhaps there really are variations in the size of the catches, which are due to differences between the persons handling the net; but it seems very unlikely that in the long run such causes could have had any appreciable effect upon the final results. If one were to set about deliberately to obtain a larger or a smaller haul, practically all he could do would be to tow the net for a longer or shorter distance, or faster or slower. The understanding was that the net should be pulled through the water only fast enough to keep the cone extended, and no faster. This condition was easily complied with in the daytime, but at night it was hard to tell whether the net was moving fast enough. I know from experience that it would have been hard to pull the net at the end of the pole much more rapidly than was necessary to keep it extended. When we consider the large number of hauls made and the length of time through which the series extended, it is hard to see how personal differences could have affected the general results.

Night collecting was subject to a source of error that did not affect the day towing. Sometimes in lowering the net into the water, air would be caught in the peak so that the end holding the bottle was out of water. This difficulty could be overcome in the daytime, but it is hard to tell how often it happened without detection during the night towing. It is certain, however, that we have hundreds of night hauls that were taken with the net properly submerged.

In connection with this work no account has been taken of possible variations due to clogging of the nets. It is well known that new nets catch more than old ones. Our nets were used as long as they were not torn. If thought worth while, it might be possible to ascertain whether there is any constant relation between size of catch and condition of the nets, since the change from 'old' to 'new' is noted in the log books.

Such factors as depth of water due to tide, currents, wave action, sand, wind velocity, and possibly other factors may have affected relative abundance of the animals, but so far as this summary of results is concerned they have been neglected. It is worth noting that records were taken with the tide-recording machine for long periods during the two years, so that the occurrence of any possible correlation between tide and abundance may be investigated, should it seem desirable to do so.

While the results of this series of plankton hauls are subject to certain sources of error, they are not affected by some other variants which relate to collecting from a boat. Allen (1921, p. 540) has given a list of conditions connected with boat collecting, and they certainly cannot apply to a set of collections made from a pier. The locations at which successive pier hauls were made could not be farther apart than the width of the pier, for in order to keep the net from being caught on the piling it was towed on the side away from the set of the surface drift. The rate at which it was drawn was practically uniform, since there could be no error due to drifting as there is in hauling from a boat. It is assumed, and is a fact which is reasonably certain, that the length of the haul was the same for all the hauls.

This particular series of collections is of unusual value in the following respects. (1) There has never been another series extending over such a long time, in which so many collections were made during each twenty-four hour period. In this particular at least, our series is unique. The work of Herdman and his associates extends through fifteen years, but their 'official' hauls were taken six times a week (Herdman, 1922, p. 141). (2) The collecting was done at a fixed location. (3) Temperature records were made for every haul, and a water sample from which the salinity was determined was taken at each haul.

My work has dealt only with the Copepoda, which are by far the predominant animals. They are listed under four groups. Two species of the genus *Acartia, A. clausi* and *A. tonsa,* were set down in the lists as species. Other small Gymnoplea have been included in a mixed group called "small calanids;" the group includes the genera *Clausocalanus, Ctenocalanus,* and *Paracalanus,* and perhaps others closely related to them, but no attempt has yet been made to segregate the genera or species. A second mixed group consists of the Podoplea, comprising such genera as *Oncaea, Oithona, Microsetella, Corycaeus,* and others. There is no doubt that valuable facts may be obtained from a study of the occurrence of the genera and species of these two mixed groups, and their separation into at least the component genera is now in contemplation. In addition to the forms mentioned, several other species occurred rarely and in small numbers, so that their presence need only be mentioned.

When the project of taking such an extended series of observations was being talked over, we felt that a tabulation of results would help in answering such questions as the following: (1) Is there a seasonal variation in abundance of copepods? If so, are the times of maximum abundance similar or different for different forms? (2) Are there diurnal (night and day) variations in abundance? If so, are there generic or specific differences as to the times of greatest abundance? (3) Is there any relation between variations in numbers of organisms and changes in such conditions in the water as temperature, for example, or salinity or acidity?

The results we have arrived at thus far partially answer the first two questions, but correlations between abundance and the other factors mentioned have not been worked out as yet.

In planning the work the intention was that E. L. Michael should handle the statistical part of the results. Before his death in 1920 he had gone over some of the collection reports and had dealt with them by methods developed by him in collaboration with McEwen. Michael's findings were never written up, however, and since his mode of working requires special knowledge of statistical procedure, it has seemed desirable to report on the collections without employing greatly refined methods of handling the data. Those of the present staff who have consulted on the matter believe that even these cruder tabulations show in a general way what has been gained during the two years, and, equally important, show also what has not been gained and whether the plan should be continued with or without modifications.

The method of computing used in preparing this summary was suggested to me by McEwen. The computations start with the average number of animals per haul, arranged under headings for each of the twenty-four months over which the observations extended and for each of the six times of day at which the collecting was done. Such an arrangement of the original data for one species is shown in table 1. The average per haul *for the two years* (last line of table) was used as a standard, and two methods were followed which may be called respectively the "ratio of the means," and the "means of the ratio." By the use of these methods coefficients are obtained which make it possible to correct the original entries, so that in dealing with the time of day relations the seasonal variability is eliminated and an estimate may be made of the reliability of the results which relate to the time of day.

TABLE 1

Average Number of Acartia tonsa per Haul, Arranged According to Months and Times of Day

Year and month	8 A.M.	Noon	4 P.M.	8 P.M.	Midnight	4 A.M.
1916						
IX	26	12	12	49	198	82
X	4	3	5	37	41	23
XI	40	12	7	74	53	130
XII	24	14	19	19	20	32
1917						
I	9	4	19	5	5	10
II	11	1	1	5	5	11
III	16	5	47	80	83	207
IV	37	10	9	46	59	63
V	4	1	34	93	63	121
VI	5	1	1	82	148	38
VII	11	0	16	97	103	65
VIII	29	36	123	237	304	168
IX	25	2	334	270	60	220
X	14	2	1	43	338	298
XI	35	4	9	32	107	105
XII	11	13	42	85	66	109
1918						
I	8	10	3	58	75	69
II	65	0	0	8	15	28
III	108	0	1	43	28	29
IV	0.3	4	18	58	26	39
V	20	10	0.5	95	76	21
VI	0	3	12	101	67	73
VII	288	947	469	915	1026	1406
VIII	41	24	26	79	175	258
Average	35	47	50	119	131	150

To give an actual example of the way in which the data were handled we may use the figures in table 1. The method of "ratio of the means" is as follows: (1) Add the average numbers of animals per haul at the six periods for the two years. (2) Divide the sum obtained by the horizontal sum of the entries for each month; the quotients are then the coefficients. (3) Multiply each of the original entries (table 1) by the coefficient for the corresponding month; the products are the values corrected for season.

The method called the "means of the ratios" is as follows, referring again to table 1. (1) The ratio of each entry in a column to the average number of animals per haul for two years as it is given in the same column is determined. This process gives a table consisting of six columns and twenty-four lines. (2) The horizontal sum of each line (step 1) is divided by 6, which gives the coefficients. (3) Each of the original entries (table 1) is multiplied by the coefficient for the corresponding month. These products are the corrected values. This method constitutes a rough check against the first one.

TABLE 2

CORRECTED DATA FOR ACARTIA TONSA, COMPARING THE RESULTS OBTAINED BY THE METHODS OF "MEANS OF RATIOS" AND "RATIOS OF MEANS."

There is also a comparison of the first with the second year.

	Number of animals per haul						Mean ann. abund.
	8 A.M.	Noon	4 P.M.	8 P.M.	Midnight	4 A.M.	
Means of ratios:							
First year	81	25	97	184	478	377	207
Second year	203	41	165	479	684	651	370
Ratio of means:							
First year	49	18	48	118	147	146	88
Second year	68	19	38	124	133	152	89
Two-year average:							
Means of ratios	142	33	131	331	581	514	....
Ratio of means	59	19	43	121	140	149	....

The mean annual abundance and the mean monthly abundance of the copepods may both be obtained from the values as corrected by either of the methods. The vertical sum of each of the six columns of corrected values is divided by 24, and the sum of the quotients is then divided by 6 to give the mean annual abundance. The mean monthly abundance is obtained by dividing the mean annual abundance by the coefficient for the corresponding month as derived by step 2 in either method.

The results obtained by using the two methods check fairly well, as differences are usually in the same direction. In table 2 there appear the final results for *Acartia tonsa* as obtained by each of the methods, but for the other forms only the averages for the two methods have been set down.

The probabilities in table 6 were determined from the corrected results by a method worked out by McEwen. The method has not been published, but it has been briefly described (McEwen, 1920, pp. 263, 273). The figures giving the probability indicate the number of times a difference would occur if the results were due to chance. When the values are smaller there is, however, less likelihood that the results are due to such a cause. The probabilities were determined from results corrected by the ratio of the means and by the means of the ratios, but only the averages are given in this paper.

RESULTS

On the whole the copepods were considerably more abundant during the second year. The totals in round numbers for the two years and for each year separately were as follows: *Acartia tonsa,* total 248,000; 86,000 the first year, and 162,000 the second; *A. clausi,* total 475,000; 182,000 the first year, and 293,000 the second; small calanids, total 330,000; 184,000 the first year, and 146,000 the second; Podoplea, total 4,350,000; 1,210,000 the first year, and 3,140,000 the second. The mean annual abundance, as given in tables 2 and 5, shows that all the forms except the small calanids were found in larger numbers during the second twelve months.

If we consider the corrected values for the six periods (see table 5) it will be noted that there is only one place (8 P.M. for small calanids) where the number of animals per haul during the dark hours is not greater during the second year. During the light hours, however, the larger numbers per haul appear more often during the first year.

It seems evident that the mixed assemblage of genera called "small calanids" constitutes a group somewhat apart from the other Copepoda in occurrence, when one year is compared with another. We cannot say much more than this until the genera and species have been segregated and the results tabulated. It is possible that there are one or two predominant forms whose distribution determines that of the group as a whole.

The values for the mean monthly abundance of the animals show results that are similar to those that are indicated by the total numbers and by the distribution through the twenty-four hours. When the mean abundance for each month is compared for the two years (see table 3), it is seen that for nine months out of twelve the numbers of *A. tonsa* were greater in the second year; in ten months out of twelve the numbers of *A. clausi* were greater in the second year; in seven months out of twelve and in eleven out of twelve larger numbers of small calanids and Podoplea, respectively, were obtained in the second year.

The mean monthly abundance shows clearly the season of the year at which the different copepods were most and least abundant. The main results may be seen in table 3. *Acartia clausi* was obtained in largest numbers during March of both years. The season of least abundance or of complete absence extends over several months of each year, always covering July, August, and September. *A. tonsa* reached its greatest abundance in August of the first year and July of the second. The smallest numbers were obtained in January and February of the first year, and in March and May of the second.

TABLE 3

MEAN MONTHLY ABUNDANCE. THE TWO METHODS OF HANDLING THE DATA WERE USED AND THE RESULTS COMBINED.

'I' means first year (1916–1917); 'II' means second year (1917–1918).

	Average number of animals per haul							
	Clausi		Tonsa		Small Calanids		Podoplea	
	I	II	I	II	I	II	I	II
September	09	0	74	114	105	80	1365	1597
October	3	23	22	69	26	54	599	756
November	81	34	61	70	13	51	378	565
December	49	125	35	91	21	166	248	2190
January	72	90	14	53	12	75	181	746
February	95	732	8	46	6	16	536	1259
March	377	1347	80	35	50	103	429	2217
April	54	1025	51	42	38	122	455	2100
May	33	329	33	28	58	58	242	1065
June	26	24	28	66	46	7	682	1254
July	0	28	82	2295	356	71	1755	3226
August	0	21	203	204	167	108	1967	1547

It is hard to say whether the fluctuations from month to month are significant, but there can be no doubt of the general fact that one of the species of *Acartia* is found in greatest numbers at the season when the other species is least abundant.

There is a good deal of irregularity in the monthly abundance of the small calanids, and the results obtained during the two years do not correspond so closely as they do with *Acartia.* During the first year the small calanids showed a well marked maximum in July and a minimum in February. There were two maxima in the second year, in December and April, with the minimum in June. In considering the reasons for these irregularities, we should not forget the possibility that the composition of this mixed group of copepods may have been relatively different in the two years. At least there is nothing to indicate that the differences between the two years may not be due to the occurrence of different genera. It would hardly be expected that the seasonal distribution would show such variability if the several species comprising the group were present in approximately the same proportions in the second year as in the first.

The Podoplea were present in largest numbers during three months of the first year, September, 1916, and July and August of 1917. They reached their minimum in January. During the second year their occurrence was much more irregular. There was a succession of larger and smaller numbers, the month of greatest abundance being July, followed by March, December, and May. The Podoplea were least numerous in November, with October and January next in order. It is impossible to say what the differences between the two years may mean. The suggestion is not out of place, hoewver, that the relative numbers of the forms making up the mixed group were so dissimilar in the two years that the mean monthly abundance must have been different. This suggestion may be verified from the hauls themselves.

TABLE 4

MEAN WEEKLY ABUNDANCE OF TWO SPECIES OF ACARTIA DURING THE SEASON OF GREATEST ABUNDANCE.

The results of the two methods of handling the data are combined. The figures give the average number of animals per haul.

	Clausi			Tonsa	
	1917	1918		1917	1918
March 1–7	557	408	July 1–7	7	306
March 8–14	835	635	July 8–14	37	226
March 15–21	940	1456	July 15–21	367	5821
March 22–28	127	1705	July 22–28	53	909
March 29–April 4	192	461	July 29–August 4	53	275
April 5–11	32	166	August 5–11	277	754
April 12–18	487	2271	August 12–18	88	242
April 19–25	346	348	August 19–25	343	226
April 26–May 2	90	260	August 26–September 1	154	75

In order to compare the two years in another way, the mean weekly abundance of the two species of *Acartia* was determined for the season when the animals were most abundant. *A. tonsa* was most abundant in July and August and *clausi* during March and April. The results appear in table 4. *A clausi* was present in largest numbers during the third week of March, 1917 (March 15–21), and during the week beginning April 12, 1918. But it should be noted that in the two weeks beginning March 15, 1918, there was a marked rise, which was followed by a drop in numbers. After that there came the rise to the maximum. In a general way the conditions of occurrence during 1917 were similar. Although the time of the actual maximum was different, it was followed by decreased numbers for three weeks, and in the fourth week after the actual maximum there appeared another marked increase which corresponded to the maximum of 1918. A comparison of the two columns in table 4 that deal with *A. clausi* will show that there is a broad similarity in the occurrence of this copepod in the corresponding weeks of the two successive years.

Acartia tonsa reached its actual maximum in the third week of July in both 1917 and 1918. For the next two weeks the numbers were relatively much reduced in both years. After that there was a noticeable increase during one week, which was followed by a marked drop (August 12–18). The close similarity between the two seasons ends there; but whatever the differences mean the points of correspondence are worthy of note.

TABLE 5

CORRECTED VALUES FOR NUMBER OF ANIMALS PER HAUL AT THE SIX PERIODS OF COLLECTING.

The results of the two methods of correction are combined.

	Number of animals per haul						Mean annual abund.
	8 A.M.	Noon	4 P.M.	8 P.M.	Midnight	4 A.M.	
First year:							
A. tonsa	65	22	72	150	312	261	147
A. clausi	97	45	97	212	199	210	143
Small calanids	140	94	81	233	99	96	141
Podoplea	1304	990	1240	1425	1353	1480	1259
Second year:							
A. tonsa	135	29	101	301	408	401	229
A. clausi	85	38	40	276	363	391	282
Small calanids	130	51	93	126	119	136	91
Podoplea	1211	884	987	1512	1439	1913	1384
Average for the two years:							
A. tonsa	100	25	86	275	360	331	183
A. clausi	91	41	63	244	281	300	212
Small calanids	185	72	87	180	110	166	216
Podoplea	1257	937	1113	1468	1396	1696	1321

In any such investigation as this, the matter of diurnal distribution is sure to come up. A casual examination of the collections will show that there are marked differences in abundance between the day and night hauls. In table 5 there is an arrangement of the corrected figures, and in table 6 are indicated the probabilities that certain of the differences in table 5 are significant.

The changes in abundance that occur between 4 A.M. and 8 A.M. and between 4 P.M. and 8 P.M. are the most important ones, since they relate to actual diurnal differences. But it is of interest to note the rather marked significance of the difference between numbers obtained at 8 A.M. as compared with noon. As is shown in table 6 the differences between 8 P.M. and midnight, and between midnight and 4 A.M., are of slight significance, but those between 8 P.M. and 4 P.M. and 4 A.M. and 8 A.M. are very strongly significant. On the whole the results show that there is a marked excess of numbers at night, and this excess is not due to chance in the cases of *Acartia tonsa* and *clausi* where the probability has been determined.

TABLE 6

TO SHOW THE PROBABILITY THAT THE DIFFERENCES BETWEEN NUMBERS OF ANIMALS PER HAUL AT DIFFERENT TIMES OF DAY ARE SIGNIFICANT

The figures are based on the corrected values and deal with the two-year averages given in table 5.

	Probability that					
	8 A.M. exceeds noon	4 P.M. exceeds noon	8 P.M. exceeds 4 P.M.	4 A.M. exceeds 8 A.M.	Midnight exceeds 8 P.M.	4 A.M. exceeds midnight
A. tonsa	.0045	.0087	.0005	.00012	.13	see note
A. clausi	.0022	.057	.00037	.0002	.13	.039
Small calanids	.0007	......	.042	.10	.044	.015
Podoplea	.0495	......	.028	.02	.....	.045

NOTE: The number of animals per haul for the two years was greater at midnight than at 4 A. M., and the probability is .165 that the difference is significant.

It will be noted in table 6 that the values under the headings "small calanids" and "Podoplea" are usually larger than those under *Acartia.* This difference is especially evident in the third and fourth columns. The probable reason for the larger values is that the small calanids and Podoplea are mixed groups. It is expected that when the species for those groups have been worked up, the day and night differences will be as great as for the species of *Acartia.*

DISCUSSION OF RESULTS

Since this paper is a preliminary one and in the nature of a report of progress, an extended discussion of the results obtained is hardly necessary. But some facts of general importance have been learned as well as some suggestions regarding methods, and these may well be pointed out. The tables show that there is considerable seasonal variation in the copepod plankton, and the question is always present whether such variability is due to changes in the sea water. It is possible that correlations may be found between the relative abundance of the animals and hydrographic conditions, but, as has been pointed out by Herdman and Scott (1908), hydrographic changes will not determine the presence of organisms at times when they are not produced. Herdman and Scott (1908, p. 193) state that many seasonal variations are caused "simply by the normal sequence of stages in the life histories of organisms throughout the year." The reasonableness of this statement seems self-evident. In studying the changes of the plankton so far as it consists of Copepoda, it is highly important to know the developmental stages of these crustacea.

The occurrence of phytoplankton undoubtedly has something to do with the occurrence of the Copepoda. The ecological relation between the two groups has not been taken up in the work at La Jolla, though extensive studies of the phytoplankton have been carried on for several years by Mr. Allen. It would be well worth while to know whether there is any relation between the maximal occurrence of a species or group of species of copepods and some component of the phytoplankton. So far as our own work is concerned, however, we must simply state that no facts have been ascertained regarding such matters. But when we consider the well established significance of both phytoplankton and copepods in the food cycle of the sea as affecting certain fisheries (see Michael, 1921, p. 555; Allen, 1921, p. 538; Herdman, 1922, pp. 166–169) the need of ascertaining whether there is a relation between abundance of copepods and, for example, abundance of diatoms, will be emphasized. Aside from its ultimate bearing on fisheries, such a question is worth investigating because of the general relationship it bears to the ecology of the copepods taken alone, since they feed upon the plant cells. Does the seasonal occurrence of the micro-crustacea depend on the occurrence of the organisms on which they feed? May not some of the variability in distribution of the copepods be bound up with irregular occurrence of their food supply? We are not in a position to answer such questions as yet, but they are interesting and important subjects for investigation.

Nothing in our results is more striking than the difference in seasonal occurrence of the two species of *Acartia*. Herdman obtained similar results in his work in the Irish sea, though his tables deal with separate genera instead of species in the same genus. Herdman found, for example, that *Temora longicornis* has its maximum in December, January, and February, while *Paracalanus parvus* is most abundant in September and least abundant in June (Herdman, Scott and Lewis, 1915, p. 233). It is almost certain that just as striking differences will be found between the genera or species of the small calanids and the Podoplea as between the species of *Acartia*.

It may be of interest to note that Herdman (1918, p. 197) found that *Acartia clausi* is most abundant in the Irish Sea from May to October, inclusive, generally reaching its maximum in June with a smaller rise in September or October. At La Jolla this copepod is most abundant in March, and not one specimen was recorded in July, August, or September of 1917. It is hard to account for such striking differences. The conditions are so complex that careful study of hydrographic and hauling data, as well as knowledge of the life history of the animal, would be necessary to give an insight into the matter.

Such of our data as relate to seasonal distribution of the copepods suggest that there is a natural sequence of events year after year. The occurrence of the animals for the twelve months from September, 1916, to August, 1917, inclusive, is not strikingly different from that in the year following. Herdman (1922, p. 145) found the same sort of thing in his work. (See also Herdman and Scott, 1912, p. 154.) While strict uniformity from year to year was lacking, the broad features of the distribution were similar. In our pier series the similarity of distribution in the two years extends even to corresponding weeks, as has been shown in table 4. Our study might be carried farther by ascertaining whether the proportions of different species to the whole catch and to each other are similar at like seasons of different years. If this should prove to be so, it would strengthen the view that there is a rather regular recurrence of phenomena year by year.

Why should seasonal distribution of marine animals be essentially different from that of terrestrial forms, such as birds? It is well known that migrating birds appear in a given locality at about the same time of year, season after season. Minor irregularities from year to year are to be expected, and yet it is true that there is a reasonably regular appearance of a given species.

So in the case of the copepods or other organisms of the plankton, the time of the maximum for one year may lag behind that of another or may occur earlier, without upsetting the view that one year is broadly like another. Surely it would never be found that *Acartia clausi* would appear in greatest abundance in the fall or that *A. tonsa* would reach its minimum in July or August. There is every reason to believe that the times of the maximum and minimum of those two species will be the same year after year.

This series of collections has shown beyond a doubt that the Copepoda found at the pier are more abundant as a group on the surface by night than by day. The evidence on this point is overwhelming for the two species of *Acartia.* The mixed groups also are present in larger numbers at night, though the differences here are not so significant as for *Acartia.* Since all the hauls were made at the surface, it is not possible to state where most of the animals are during the day; but there cannot be any doubt that the appearance of the larger numbers at night is due to an actual increase in the surface population, and not to inability of the animals to avoid the net in the dark.

The diurnal migration of plankton animals is such a well-known phenomenon that much experimental work has been done in making attempts to ascertain the causes of their movements. *Acartia clausi* and *A. tonsa* have been worked with in the laboratory (Esterly, 1917; 1919, pp. 16–22), and it has seemed from the experiments made there that a possible factor in the migrations is a physiolagical rhythm. Responses to external stimuli, at any rate, do not afford an adequate explanation. So far as the study of the pier collections has gone, the cause of the greater abundance at the surface at night is not indicated, although the fact of the diurnal change is firmly established. It remains to be seen whether more elaborate correlations will give a clue to the reason for the daily rhythm in the sea.

Nevertheless, as has been so often urged in publications from the Scripps Institution, the natural history of the plankton cannot be known until abundant records of both field and experimental observations are available. No amount of experimental work could show that *tonsa* is most abundant in July and August and *clausi* in March. And field observations would never bring to light the physiological rhythm that obtains for both species. It is now possible, for the first time, to set about an investigation of the habits of these two plankton copepods in the light of accurate field data as well as of experimental data.

It may be of interest to call attention to a suggestion that came from the laboratory observations. It was thought that the behavior of the two species of *Acartia* gave reason for believing that the numbers of animals at the surface would be greater during the colder months (Esterly, 1919, p. 22). But our field data show that only *clausi* is most abundant when the water is coldest (March is one of the three coldest months), while *tonsa* is most abundant in July and August when the water is warmest. This instance shows how necessary it is to have field data to check experimental observations.

In conclusion it should be again pointed out that the purpose in mind in taking this series of collections was not to determine the actual numbers of animals. The aim was to study daily, seasonal, and yearly fluctuations, and to discover whether they were related to variations in environmental conditions; and, if there were such a relation, to ascertain the effect of changes in the different factors. It is believed that the samples obtained are adequate and representative, and that the methods employed are sufficiently reliable to reveal certain broad, fundamental facts. It is uncertain how generally applicable the results are, for in other localities other conditions would prevail. But the investigations have undoubtedly given us a trustworthy view of what may be expected at the pier of the Scripps Institution. As regards methods and suggestions about procedure, it would be difficult to add to what has been said by Allen (1921, pp. 538, 541, 553). It seems perfectly evident that the problems connected with study of the marine plankton cannot be solved until collecting has been done continuously over a long period of years. While our series, which runs through two years is valuable, it is not extensive enough. I believe that when such work is undertaken it should be planned to cover at least ten years. It is doubtful whether there is any need of taking as many hauls in a day as we did, but I am convinced that one haul during daylight and one during the night, at given times, is the least that can be expected to give adequate returns. Collections made at such intervals would undoubtedly be enough to enable us to detect unusual occurrences which might be missed if hauls were taken less frequently. Furthermore, hauls made at some level below the surface, at the same time that the surface hauls are taken, would be extremely valuable. But the most important thing is an unbroken continuity of collecting after the series is once started. Time of collecting, location of stations, kinds of nets, methods of dealing with the data—all these are of secondary importance in comparison with continuity and extent of the series.

SUMMARY OF RESULTS

1. The series of plankton hauls extends over two full years and consists of over 3400 catches. All were surface hauls.

2. The copepods were more abundant at the surface during the second year, that is, from September, 1917, through August, 1918.

3. Two species of *Acartia, clausi* and *tonsa,* are sharply set off from each other in seasonal abundance. *Clausi* is most abundant in March and April, *tonsa* in July and August, while *clausi* is least abundant in July, August and September, and *tonsa* is least abundant in the early part of the calendar year. (See table 3.)

4. The two years of collecting resemble each other even as to the weeks when the species of *Acartia* were most abundant, during the months when they occurred in largest numbers. (See table 4.)

5. There is a very marked increase in abundance of all the Copepoda in the night hauls, and such differences are markedly significant in the case of the two forms of *Acartia.* (See tables 5 and 6.)

6. The facts obtained regarding the seasonal occurrence of *Acartia* suggest that there is a natural and regular sequence of events year after year.

Occidental College, Los Angeles, California.
Transmitted February 8, 1923.

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STUDIES ON MARINE DIATOMS AND DINOFLAGELLATES CAUGHT BY AID OF THE KOFOID BUCKET IN 1922

BY

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STUDIES ON MARINE DIATOMS AND DINOFLAGELLATES CAUGHT BY AID OF THE KOFOID BUCKET IN 1922

BY

WINFRED EMORY ALLEN

(Contribution from Scripps Institution for Biological Research of the University of California)

INTRODUCTION

This is the second paper in an annual series dealing with material collected by boat at two certain stations located respectively ten and five miles directly seaward from the pier belonging to the Scripps Institution, about seventeen miles from San Diego, California. The methods of work were the same as in 1921 (Allen, 1923) and the routine was nearly the same. The most important change in collecting was the addition for each day of a closing bucket catch at the depth of forty meters. The operations occupied parts of May, June, and September.

The boat (the *Kaiyo*) usually left the pier about 5:30 A.M. and ran directly to Station I, ten miles out. There the work of collecting micro-plankton was adapted to the requirements of the hydrographic and other observations, but in most cases the Kofoid closing bucket was lowered to the forty meter level by a little after 7:00 A.M. After being emptied through the filtration net of No. 25 silk bolting cloth it was filled at the twenty meter level. Lastly, it was used in taking a sample of water at the surface except when that sample could be more conveniently taken by dipping with an ordinary pail. Since the Kofoid bucket contains five gallons of water that was the amount uniformly filtered.

The same order of sampling was afterwards followed at Station II located five miles out. Sometimes the order was varied at one or both stations and occasionally sampling was done between the stations or at depths other than those mentioned above.

GENERAL DISCUSSION

As in 1921, it was found that diatoms were distinctly more numerous than dinoflagellates throughout the May-June period in almost all catches at the various levels (table 1). The trend of distribution, however, was very similar in the two groups. Dinoflagellates as well as diatoms were fairly numerous in the catches when the series was first begun on May 18 and, like the diatoms, they decreased somewhat in numbers until about the middle of June, when increase in both groups occurred rather suddenly. This similarity was roughly true at all three levels. The range of change in production was greatest at the surface and the twenty meter levels (figs. 1 and 2, Station I and Station II).

TABLE 1

TABLE TO SHOW AVERAGE NUMBER PER LITER OF DIATOMS AND DINOFLAGELLATES IN SAMPLES OF SEA WATER FROM THREE DEPTHS AT STATIONS I AND II, 1922

	Surface	20 meters	40 meters
May-June			
Station I			
Number of catches	34	31	33
Average per liter			
Diatoms	13,731	48,739	3,393
Dinoflagellates	416	267	143
Station II			
Number of catches	34	31	31
Average per liter			
Diatoms	15,249	52,226	7,409
Dinoflagellates	2,425	275	146
September			
Station I			
Number of catches	11	11	9
Average per liter			
Diatoms	41	39	245
Dinoflagellates	432	152	763
Station II			
Number of catches	11	11	10
Average per liter			
Diatoms	170	653	7,220
Dinoflagellates	4,341	366	333

In spite of such similarities as those just mentioned, it has been decided that the two groups have not enough in common to be acceptably treated as a general population of photosynthetic organisms.

Consequently they will receive separate treatment hereafter, the diatoms being given primary consideration because of their numerical superiority and more typical synthetic activities.

In September the average number of dinoflagellates to the catch was considerably larger than in May-June excepting for the twenty meter level at Station I. On the average, dinoflagellates outnumbered the diatoms in September also except for the forty meter level at Station II. Both groups were represented by smaller numbers in the latter part of September than at the middle of the month.

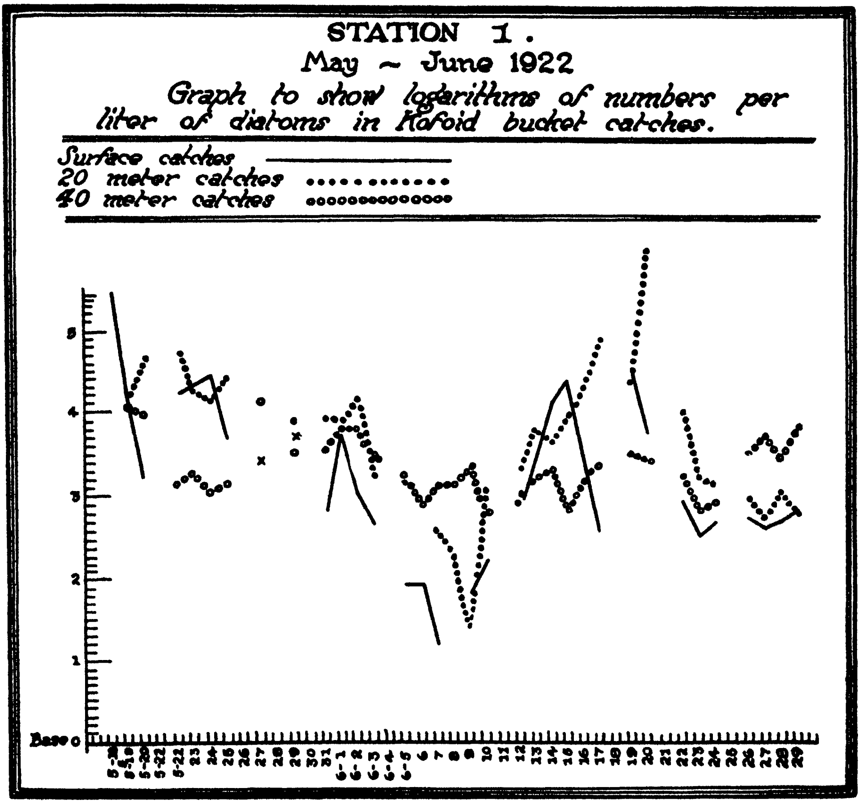

Fig. 1

In the matter of productivity at different levels the general showing is considerably different from that of 1921. In May-June, 1922, diatoms were distinctly more numerous at the twenty meter level, whereas in 1921 diatoms were found in largest numbers at the surface. Dinoflagellates were found most numerous at the surface and least so at forty meters, whereas in 1921, at Station I, there was a slightly larger number at twenty meters than at the surface. A few supplementary catches at intermediate levels (tables 2 and 3) strengthen the indication that production in the 1922 series was greatest near or above the twenty meter level, and seldom great below the thirty meter level (see also figs. 1 and 2, Station I and Station II).

In September, 1922, the conditions were different in another way. The total population of diatoms was small, being most numerous, on the average, at forty meters at both stations. At Station I dinoflagellates were taken in larger numbers at forty meters, although at Station II the most were found at the surface, as in 1921. The record of the averages for both May-June and September (table 1) gives a fairly good idea of the trend in the whole series of catches in 1922.

TABLE 2

DIATOMS

Miscellaneous depths. Numbers per liter.

	Station I			Station II		
	June 1	June 12	June 26	June 1	June 19	June 26
Surface	5,502	868	594	574	23,072	506
5	2,240	1,274	......	574	235,586	......
10	2,520	826	1,848	588	486,069	748
15	21,504	602	......	560	....	......
20	8,736	2,296	1,012	15,960	360,322	2,068
25	21,831	......	......	4,998	....	......
30	....	1,512	......	......	101,016	......
35	11,186	......	......	......	....	......
40	7,208	966	3,498	3,822	65,814	3,300
50	4,200	......	......	......	....	......
55	....	196	......	......	2,646	......

In both May-June and September the average numbers caught, of both diatoms and dinoflagellates, were greater at Station II than at Station I at all levels (table 1). Unpublished results of chemical studies at the two stations (made by E. G. Moberg) show little difference except that hydrogen ion concentration is slightly lower at five miles than it is at ten. Lacking information as to other influences, one is immediately pointed to the conclusion that Station II (five miles out) was more favored by organic content of the water or other shore effects than was Station I (ten miles out). This conclusion, however, in spite of its ease of application should remain open to question until more firmly established. Indeed, its application is somewhat confused by the fact that average numbers at twenty meters at Station I were much greater than average numbers at the surface at Station II (table 1).

In 1921 it was noted (Allen, 1923, p. 77) that greater numbers of species were recorded at the twenty meter levels than at the surface. In May-June, 1922, the number of species of diatoms at Station I was nearly the same at all three levels, but the number was greatest at twenty meters at Station II. In September the number of species of diatoms was greatest at the forty meter level at both stations. The number of species of dinoflagellates was greatest at the surface at both stations in May-June and at Station II in September. The limited evidence of the two seasons shows a tendency of the larger number of species of diatoms to stay some distance below the surface while the larger number of species of planktonic dinoflagellates tend to remain at or near the surface. In considering this matter of dis-

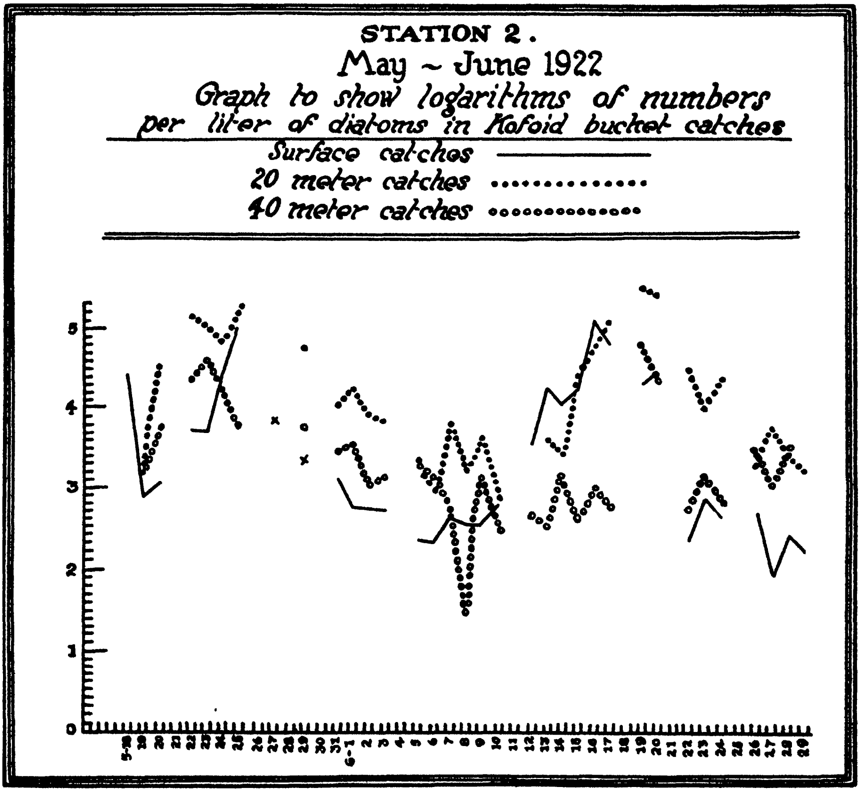

Fig. 2

tribution of species, weight should be given to the fact that counts are made under relatively low magnification and segregation of species is very imperfect. It will be interesting to see if further studies support or contradict the evidence just stated.

TABLE 3

Dinoflagellates

Miscellaneous depths. Numbers per liter.

	Station I			Station II		
	June 1	June 12	June 26	June 1	June 19	June 26
Surface	308	126	462	252	8,553	484
5	238	56	......	280	1,792	......
10	266	168	308	252	2,553	418
15	294	112	......	322	....	......
20	84	98	286	168	56	418
25	168	......	......	196	....	......
30	......	42	......	......	224	......
35	56	......	......	......	....	......
40	140	14	242	154	84	110
50	70	......	......	......	....	......
55	......	56	......	......	112	......

DIATOMS

A total of fifty-two species of diatoms was provisionally recorded (see Allen, 1923, p. 77) for the combined series. Of these, only ten (exclusive of the catch-all assemblage, *Chaetoceras* sp.) reached prominence sufficient to give them a place in the first five at either station or any level. Of the ten, only one, *Nitzschia seriata* Cl., was included in the first five at all levels at both stations in May-June. In September it was missing at the ten mile station at the surface and at twenty meters, although present at forty meters and at all levels at the other station. *Chaetoceras debile* Cl. (including *Ch. curvisetum* Cl.) was in the first five in May-June in all cases except the forty meter level at Station I, where it was sixth. In September it was prominent only at forty meters at Station II, corresponding very closely in occurrence with *Nitzschia seriata* Cl.

Chaetoceras criophilum Castr. was among the five most prominent at the twenty and forty meter levels at both stations in May-June, but it was either absent or not conspicuous at other times. *Eucampia zoodiacus* Ehr. was most peculiar of all in that it was taken very few times at these stations but in very large numbers in three catches (over 1,000,000 to the liter at Station I, twenty meters, on June 20; over 300,000 at Station II, twenty meters, on June 19, followed by over 200,000 on June 20; and over 58,000 at Station II, forty meters, on June 19, followed by over 20,000 on June 20). This diatom is very easily recognized, so that there is no question as to its identity. On June 21, in a non-serial catch from the twenty-five meter level at the entrance to San Diego Bay, this species was found in numbers of about 2,720,000 cells to the liter.

The six other species which deserve mention were *Chaetoceras decipiens* Cl., prominent at the surface only at both stations, *Dactyliosolen tenuis* Cl., at forty meters only at Station I, *Lauderia borealis* Gran., at forty meters at Station II in September only, *Skeletonema costatum* Grev., at forty meters, Station I, in September only, *Thalassiothrix acuta* Karst., at the surface, Station I, only in May-June, and *Thalassiosira subtilis* (?) Ostf., at forty meters, Station I, only in May-June.

Five of the ten species mentioned above had somewhat similar prominence in June-July, 1921, but *Chaetoceras scolopendra* Cl., which then was first at twenty meters at Station I, was not among the first five in any case in 1922.

At two different times surface catches were taken at a point fifteen miles seaward from the pier. In both cases the catches were smaller than they were on the same days at the ten mile station. Occasionally surface catches were taken at points between the regular stations or farther inshore. From these there is some indication that slightly larger surface catches may be expected as the shore is approached. There were, however, some exceptions to this which show that uniform increase is not to be expected any more than is uniform distribution.

Catches taken on a round trip to San Diego in June not only indicated heavier production inshore but much heavier production at the entrance to San Diego Bay. At the whistling buoy near Point Loma, a large catch was made at the surface, but one at ten meters was still larger, and another at twenty-five meters much larger. The extraordinary numbers of *Eucampia zoodiacus* Ehr. in all three of these catches make it very probable that this may have been an unusually concentrated swarm. Since, however, *Eucampia* was also unusually abundant at the regular stations for a day or two at about the same time, it may be supposed that it merely found exceptionally favorable conditions near Point Loma. This view is supported by the fact that *Chaetoceras debile* Cl. and *Nitzschia seriata* Cl. showed similar differences on a smaller scale.

Surface catches taken on a run thirty miles northward late in June gave no certain indication of anything except that catches of diatoms differ greatly in numbers at different points. There is not the slightest indication of uniform distribution over a wide area, although one may properly suppose that conditions may sometimes arise, just as they do on land, whereby some one plant is enabled to reach a very heavy production and therefore an apparent uniformity over a wide stretch of territory.

DINOFLAGELLATES

Although in most catches dinoflagellates were not numerous in either May-June or September, a total of thirty-seven species was recorded. Of these only seven reached sufficient prominence to be listed with the first five in average production at any level. Of the seven *Ceratium tripos* (O. F. M.) was the only one prominent in May-June at all levels at both stations. In September it was among the first five only at the surface at Station II. In no case was the identification positive, the lateral horns usually being broken off close to the body. *Prorocentrum micans* Ehr. was among the first five at twenty and forty meters at Station I and at the surface at Station II in May-June and at all levels at both stations in September. *Dinophysis homunculus* Stein was among the first five at all levels at both stations in September. The other species represented in the first five at some place in the two periods were *Peridinium divergens* Ehr., *Peridinium ovatum* (Pouch), *Peridinium steinii* Jörg., and *Ceratium furca* (Ehr.). No catch of dinoflagellates was so great as 30,000 to the liter, but this poor showing is probably due to the fact that both series of catches were taken at the wrong season for large numbers.

PHYSICAL AND CHEMICAL CONDITIONS

Although light is recognized as a prime factor in determining the quantity and distribution of diatoms (without considering other organisms), we have not yet developed a satisfactory method of identifying its influence in this area. Recent experiments in the Puget Sound region (Shelford and Gail, 1922), which show optimum light conditions for brown algae to be from five to twenty meters below the surface, suggest the possibility that the influence of light tends to best production of diatoms within those limits. Maximum catches (average and individual) at twenty meters in 1922 at both of our stations may indicate that the influence of light was not offset by that of other factors to such an extent as to prevent it from determining the maximum at or above the twenty meter level.

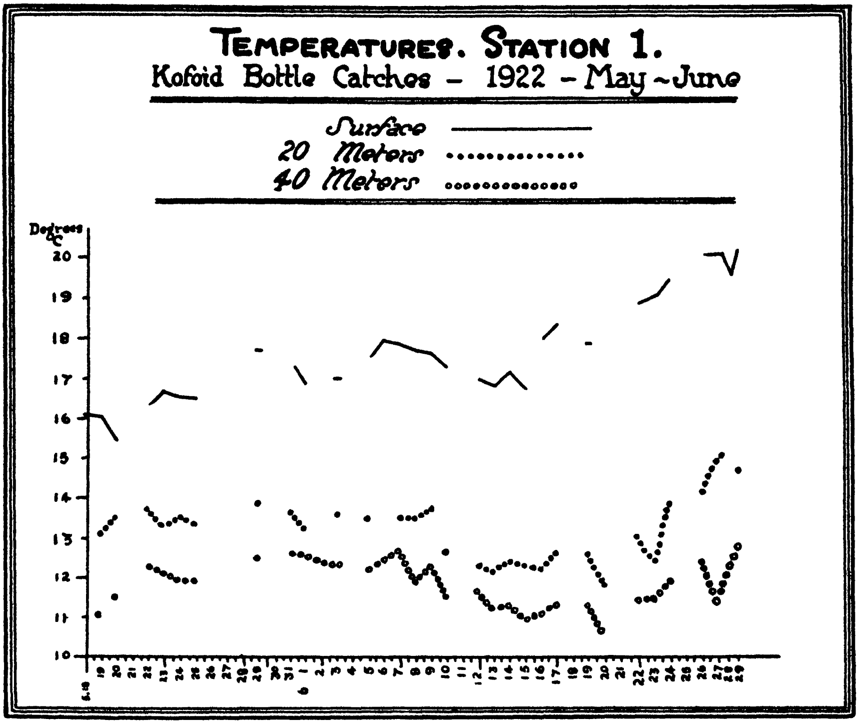

Fig. 3

Hydrographic observations in 1922, as in 1921, were made on a plan somewhat different from that of the biological observations and there is still no fully satisfactory basis of detailed comparison for the results of the two types of studies. Inasmuch as salinities, specific gravities, and other items of hydrographic record follow very much the same trend of variation from day to day as that taken by temperature, it seems to be sufficient for present purposes to confine attention mainly to temperature (figs. 3 and 4, Station I and Station II).

Whether it be direct or indirect, there seems to have been in 1922 some very definite connection between changes in temperature and changes in magnitude of the catches. This connection is obvious when comparing the graphs in figures 1 and 2 with those in 3 and 4. From mid-May to nearly mid-June there was fairly consistent decrease in production of diatoms at both stations and at all levels. The third week in June brought a rapid rise, followed in the fourth week by an equal decrease. Surface temperatures had been consistently rising and twenty and forty meter temperatures had varied consistently about a mean up to the third week in June, when there was a marked reduction at both stations at all levels. Pier temperatures varied along lines similar to the surface temperatures.

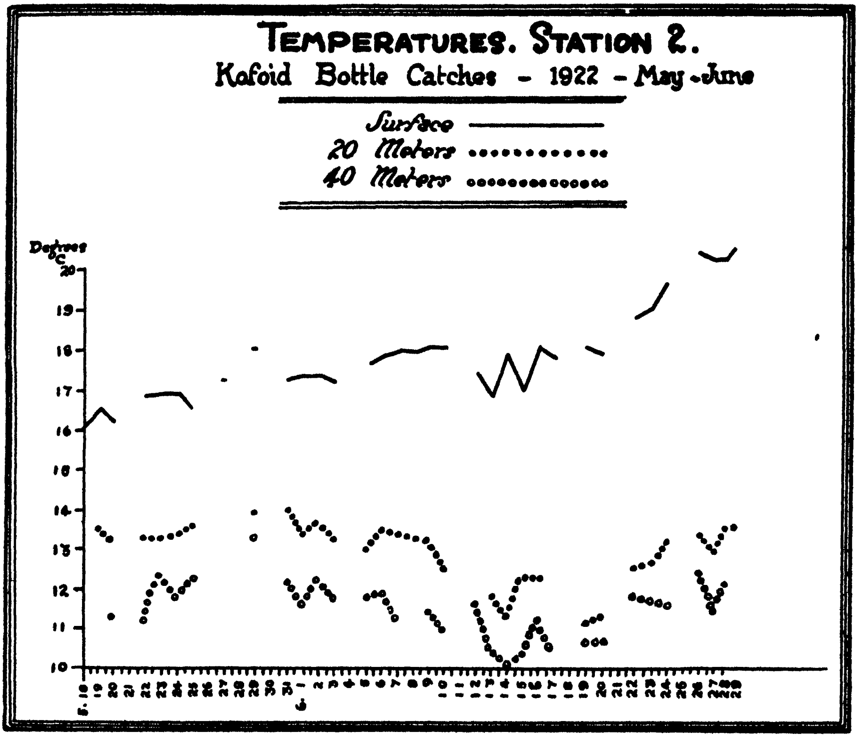

Fig. 4

This showing of larger catches in lowered temperatures is contrary to what was noted in 1921, when the principal increase in catches came close to rising temperatures (although the largest single catches were made in reduced temperatures, Allen, 1923, pp. 78–79). While such contradictory results make it very difficult to see the mode or extent of direct influence of temperature, they do not weaken the view that temperature is in some way a leading factor. Furthermore, the difference in temperature between the surface and the other two levels is much greater than the fluctuations at any level during the period of collecting yet most of the species seemed to thrive at all levels even when their optimum was indicated at one. With such points in mind it seems possible, if not probable, that the lower temperatures from June 11 to June 22 at Stations I and II and at the pier indicate an extensive drift movement of water rather than an upwelling, such as we have usually assumed to be responsible for lowered temperatures. If local upwelling were responsible, the temperatures at twenty meters and forty meters ought to be much more nearly the same than usual and the surface should show less difference from the other two. Presumably, also, local upwelling should force the main diatom population close to the surface.

Chemical records are still insufficient to attempt to trace the influence of given chemical factors upon distribution of the microplankton population. In the case of hydrogen ion concentration, for example, it is practically impossible to say to what degree its fluctuation in this period is due to temperature, to flow of currents, to upwelling, or to fluctuations in the numbers and activities of photosynthetic and nonsynthetic organisms, or to what degree it influences fluctuations of other factors of the ecologic complex.

CONCLUSION

The conclusions stated for 1921 (Allen, 1923, p. 79) hold equally well for 1922. It may be worth while to note that the similarities of the records of collections from the three levels convincingly indicate that the methods employed are correct.

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STATISTICAL STUDIES OF MARINE DIATOMS OF THE SAN DIEGO REGION COLLECTED BY U.S.S. PIONEER IN MIDWINTER 1923

BY

WINFRED EMORY ALLEN

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STATISTICAL STUDIES OF MARINE DIATOMS OF THE SAN DIEGO REGION COLLECTED BY U.S.S. PIONEER IN MIDWINTER 1923*

BY

WINFRED EMORY ALLEN

(Contribution from the Scripps Institution for Biological Research of the University of California)

INTRODUCTION

By far the most important point in connection with the statistical studies here presented is the fact that three scientific organizations successfully coöperated in accumulating and handling the material. The United States Coast and Geodetic Survey, by using its facilities for collecting and by employing the methods of the Scripps Institution for surface observations and collections, was able to gather a large amount of important material; the Carnegie Institution contributed its facilities for taxonomic study; and the Scripps Institution has contributed its facilities for statistical study of the material. The Coast and Geodetic Survey could not (if it would) handle the material without expanding its resources and applying them in lines subsidiary to the purpose of its existence. The Carnegie Institution could not readily adapt its resources and facilities to the collecting and the statistical examination. The Scripps Institution could not do such collecting and make the taxonomic studies without much greater resources than it has available. Furthermore, much of the information thereby procured is not otherwise obtainable. The three working together can therefore turn out a piece of good scientific work without overstepping bounds or straining resources, and can gain from their coöperation an increased mutual understanding and respect.

Early in 1923 the U. S. S. Pioneer of the United States Coast and Geodetic Survey, which had been doing topographic work in the vicinity of Scripps Institution, La Jolla, California, made two round trips from San Diego to Cortes Bank, holding a variable course not far from Lat. 32° 35′ N. Forty-five samples of microscopic plankton were collected. Each sample consisted of organisms caught by filtering five gallons of water (dipped from the surface of the sea) through a small net of No. 25 silk bolting cloth. On the first round trip catches were made on January 22 and 23, outbound, and on February 2, inbound; on the second trip, outbound on February 5 and 6, inbound on February 8 and 9. These collections were turned over to the Scripps Institution for statistical study. For convenience in discussion the catches are arbitrarily assigned to five sections of about eighteen miles each. Beginning with Long. 117° 20′ W, the sections were numbered consecutively to Long. 118° 40′ W, each section including 20′ of longitude. Table 1 shows fairly well the surface distribution of the diatoms in these sections.

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TABLE 1

DIATOMS

San Diego to Cortes Bank—January-February, 1923
U. S. S. Pioneer

First Round Trip

Section	1	2	3	4	5
Catches	682	0	0	0	180
	132	0	0	18	18
	198	270	576	198	0
	54	5,984	432	450	90
	286	......	......	......	13
Total	1,352	6,254	1,008	666	301
Average	270	1,563	252	166	60

Average to the catch for first trip, 435 to the liter.

Second Round Trip

Section	1	2	3	4	5
Catches	3,888	2,772	264	484	
	7,150	18,898	198	132	
	2,904	242	3,740	528	
	15,104	4,576	229,188	......	
	....	16,038	......	......	
Total	29,046	42,526	233,390	1,144	5,456
Average	7,261	8,505	58,347	381	779

Average to the catch for second trip—13,456 to the liter.

Details of the hydrographic data do not have demonstrable connection with changes in the diatom population. Specific gravity was extremely low once and temperature extremely low four times (as compared with the mean) on the first trip. If these extremes be dropped from consideration it may be said that both temperature and specific gravity were slightly lower on the second trip than on the first. There was also much more clear weather, especially at the time of lower temperature, on the second trip. The larger catches of the second trip were all made at temperatures slightly above or very near the mean.

MATERIAL COLLECTED

As shown by table 1 catches on the first trip were very light, only one (made about twenty-three miles west of San Diego) containing more than 1000 to the liter. On the second trip all catches in the first section were over 2000 to the liter, four out of five in the second section were over 2000, and two out of four in the third section were over 3000 to the liter. While section four (directly south of San Clemente Island) and section five (nearer to Cortes Bank) yielded very small catches, the catches were nearly all larger than catches from these sections on the first trip.

Such conditions obviously indicate not only an abrupt change from the non-productive winter season, but also that the causes of change were operative over an area nearly ninety miles in width, extending from the coast line two-thirds of the distance across the continental shelf. Non-microscopic, casual inspection of material collected at the La Jolla pier shows close agreement with this indication in that production increases with the beginning of February and reaches its highest for that period about February 12.

Diatoms.—On the first trip twenty-six species of diatoms were caught, on the second trip, thirty-five. These included practically all of the species which attain numerical prominence at any season. It therefore seems probable that prominence of particular species at certain seasons is due to especially favorable conditions rather than to wholesale migration into the local field. I do not think, however, that this view invalidates the supposition that drift currents may sometimes sweep a large population into any given area. Either or both may account for increased production, according to circumstances.

The exceptional catch of more than 200,000 to the liter at a point about seventeen miles southeast of San Clemente Island seems somewhat abnormal in comparison with all the others of the series. *Chaetoceras scolopendra* Cl. made up more than half of this catch, and, with other small species of *Chaetoceras,* comprised almost the whole number, although *Bacteriastrum varians* Lauder numbered over ten thousand. Evidently this is a good example of localized swarms of minute organisms which we know to occur in open waters.

Except for the large catch in section three, nearly all the larger catches were made in sections one and two, and less than forty miles from shore. In a general way this fact supports the common supposition that production of plants, even in open water, is greater near the coast.

Most of the catches were made at intervals of one hour. Since they differ markedly in numbers, it is evident that distribution throughout the area was not uniform even in those cases where hydrographic data suggested the possibility of approximating to uniform environmental conditions.

Dinoflagellates.—The catches were also examined for dinoflagellates but in no cases were their numbers great enough to have any statistical value. All that can be said is that some were present.

It was very fortunate that the U. S. S. Pioneer made two round trips over the same ground in quick succession for it showed exceptionally well that within a very few days production may radically change over a wide area in the winter season. This showing has additional value because of the fact that it ran approximately parallel with a similar change at the pier and makes it more than ever probable that seasonal changes in production at the pier give a fair basis for judging the general character of seasonal changes in this oceanic area.

Transmitted June 11, 1923.

THE LIFE CYCLE OF OITHONA NANA, REARED EXPERIMENTALLY

BY

HELEN E. MURPHY

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THE LIFE CYCLE OF OITHONA NANA, REARED EXPERIMENTALLY

BY

HELEN E. MURPHY

(Contribution from the Scripps Institution for Biological Research)

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I. INTRODUCTION

An examination of a series of surface collections of zooplankton made at the pier of the Scripps Institution, La Jolla, California, indicates that *Oithona nana* is numerically the dominant Copepod throughout the year. The possibility that this is a hardy species, together with the fact that no single specimen of marine copepod has been bred through the successive stages from egg to adult, led to rearing experiments, the results of which are summarized in the present paper.

II. REARING EXPERIMENTS

Rearing jars.—Flat-bottomed glass stender dishes 60 mm. in diameter and 30 mm. high were used as rearing jars. These proved to be large enough for proper growth of the specimens, and were easily oriented on the stage of the binocular microscope. Unnecessary handling of specimens was thus eliminated. The containers were two-thirds filled with unfiltered ocean water and placed in indirect north light. Except for a slight addition to compensate for evaporation, the water was unchanged during the entire experiments. Fungus growth was controlled by increasing the intensity of light. Strong light caused the specimens to become very agitated. To prevent this, a portion of the jar was always kept shaded. A piece of fresh kelp about 1 mm. square was added to each jar and allowed to remain for a week. Then it was removed, and a fresh bit added. There was a fair growth of the diatom of the genus *Navicula* throughout the experiment, as well as of small Protozoa, in the aquaria.

Food.—Several specimens of *Oithona nana* collected at 8 a.m. showed yellowish brown organic débris, similar in color to kelp, in the stomach. A few pieces of the diatom *Thallasiothrix* were found. In two cases bits of copepod nauplii were recognizable.

In the laboratory, adult specimens ate freely of the small bits of fresh and decaying kelp, and also fed somewhat—though far less than of the kelp, on the diatom *Navicula*. Nauplii began eating this kelp almost as soon as hatched.

TABLE 1

Summary of Results of Rearing Experiments, Oithona nana, in 60 mm. Stender Dishes, Unfiltered Ocean Water

Exp A 1♀ with eggs	Exp B 1♀ 1♂	Exp C 1♀ with spermatophores	Exp D 1♀ 1♂	Exp E 1♀ 1♂	Week
Eggs thrown off	Eggs	Eggs	dead	Eggs	1
					2
		11 Nauplii	dead		3
No results	18 Nauplii		No results	18 Nauplii	4
					5
					6
		9 Copepodid I			7
	11 Copepodid I			8 Copepodid I	8
					9
					10
		3♀ 4♂			11
	6♀ 3♂			3♀ 2♂	12

Material.—Specimens sorted from the 8 a.m. surface collection at the pier were left in a large finger bowl of ocean water for twenty-four hours. Individuals in good condition were then transferred by means of a capillary pipette to rearing jars that had been previously prepared.

Each specimen was examined daily in the stender dish under a binocular microscope, and the results recorded. As soon as hatched, the nauplii were transferred to separate jars. After each molt the cast skin was removed, measured, and put into a vial with corresponding number. In this manner a complete record was kept of each specimen.

Table 1 is a summary of the results of the rearing experiments with *Oithona nana*, first cycle.

A second cycle was then started from reared adults. Two females, B7 and B9, were transferred to a finger bowl with two males, E7 and E13 (table 1). Eight days later one female was carrying egg masses. From these, nine nauplii hatched, and two females and two males reached maturity. The life cycle from adult to adult was completed in ten weeks.

III. STAGES OF DEVELOPMENT

The eggs of *Oithona nana* are carried by the female in two sacs until the nauplii hatch. The number of eggs to a mass ranges from 5 to 11. In experimental jars the nauplii appeared in 11 to 18 days.

TABLE 2

SUMMARY OF LENGTH OF STAGES AND BODY LENGTH, OITHONA NANA, REARED SPECIMENS

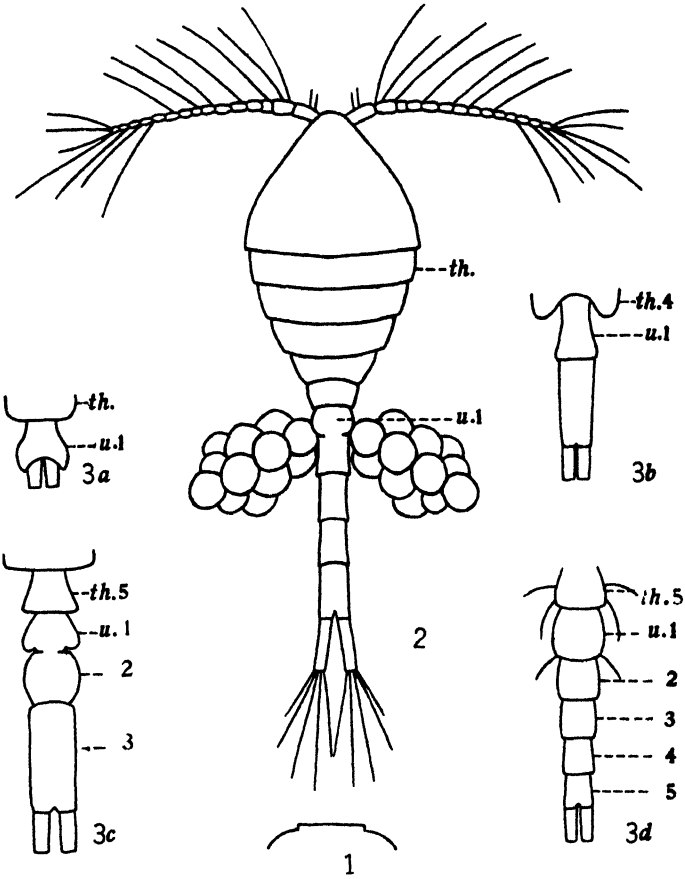
	Stage	Av Length, Days	Average length body	
			♀ mm	♂ mm
Nauplius	1	1	0 04	0 04
	2	4	0 075	0 075
	3	6	0 097	0 09
	4	4	0 12	0 11
	5	5	0 15	0 13
	6	6	0 19	0 15
Copepodid	1	5	0 20	0 19
	2	6	0 32	0 26
	3	5	0 38	0 34
	4	6	0 48	0 40
	5	6	0 52	0 45
Adult		(54 total)	0 55	0 48

There are six naupliar, and five copepodid, stages before the animal is fully formed. The complete number was recorded for 12 females and 9 males, as shown in table 1.

Table 2 is a summary of the average length in days of each stage, and of the average body length for each stage of the males and females reared to maturity.

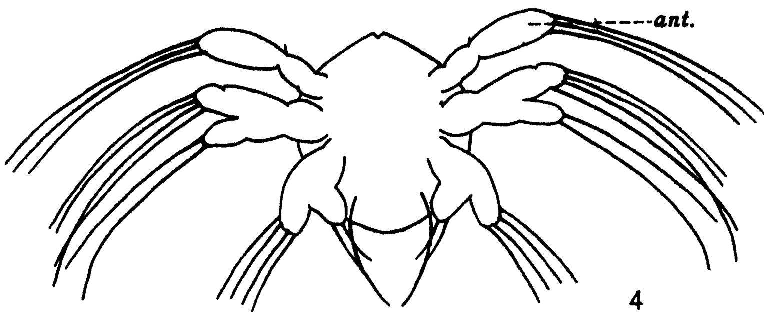
From this table it is clear that the difference in size between male and female is evident as early as naupliar stage 3. The adult measurements of the reared specimens are within the limits of the species as stated by Giesbrecht (0.5–0.65 mm.; 0.48–0.57 m.), though somewhat smaller than those of specimens taken from the pier collections.

The square-cut front of the head of the male (fig. 1) as opposed to the bluntly rounded head of the female (fig. 2), is recognizable at naupliar stage 3. Segments one and two of the female urosome are partially fused. The constriction between the two segments is, however, clearly visible.



Figs. 1–3, camera lucida drawings. Abbreviations: *th.*, thorax; *u.*, urosome. Fig. 1, front of head, male, × 250. Fig. 2, adult female, dorsal aspect, × 125. Fig. 3, Thorax and urosome in part, dorsal aspect: *a*, copepodid stage 1, male, × 250; *b*, copepodid stage 2, male, × 212; *c*, copepodid stage 3, female, × 212; *d*, adult, male, × 150.

A minute examination of specimens reveals differences in the segments of the appendages and number of bristles in the various stages, as well as in the more obvious characters of segmentation, and number of appendages. The following key summarizes the general diagnostic characters for the immature stages of this species, which are clearly evident in an enumeration of zooplankton organisms.



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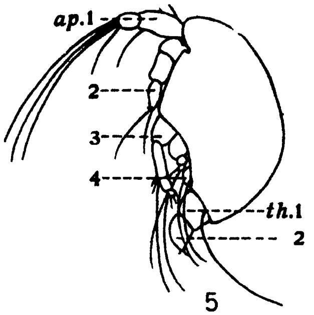

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Figs. 4–5, camera lucida drawings. Abbreviations: *ant.*, anterior antenna; *ap.*, appendage. Fig. 4, nauplius stage 1, ventral aspect, × 700. Fig. 5, nauplius stage 5, lateral aspect, × 212.

KEY TO GENERAL DIAGNOSTIC CHARACTERS, IMMATURE STAGES, OITHONA NANA

A_1. Urosome present (fig. 2) .... COPEPODID
- b_1. Urosome of 1 segment; 3 thoracic segments (fig. 3*a*) .... Stage 1
- b_2. Urosome of 2 segments (partially fused in ♀, fig. 2); 4 thoracic segments (fig. 3*b*) .... Stage 2
- b_3. Urosome of 3 segments; 5 thoracic segments (fig. 3*c*) .... Stage 3
- b_4. Urosome of 4 segments .... Stage 4
- b_5. Urosome of 5 segments.
  - c_1. Anterior antennae reaching to anterior margin of third thoracic segment .... Stage 5
  - c_2. Anterior antennae reaching to posterior margin of third thoracic segment (fig. 2) .... Adult

A_2. Urosome absent (figs. 4, 5) .... NAUPLIS
- b_1. Body segmented.
  - c_1. Body with 3 pair of appendages .... Stage 3
  - c_2. Body with 4 pair of appendages.
    - d_1. Thorax of 1 segment .... Stage 4
    - d_2. Thorax of 2 segments (fig. 5) .... Stage 5
  - c_3. Body with 6 pair of appendages, 3 thoracic segments .... Stage 6
- b_2. Body not segmented.
  - c_1. Anterior antenna with 3 bristles on distal segment (fig. 4 ant.) .... Stage 1
  - c_2. Anterior antenna with 4 bristles on distal segment .... Stage 2

IV. CONCLUSION

Twelve female and nine male specimens of *Oithona nana* Giesbrecht were reared from egg to adult. Six naupliar and five copepodid stages were definitely established in each specimen.

These rearing experiments warrant the following suggestions:

(1) Some of the hardier marine copepods may be reared without expensive apparatus and methods.

(2) Accurate record may be kept of single individuals.

(3) Results may be given in form available for practical use in enumeration of the zooplankton.

MORPHOLOGY OF THE DIGESTIVE TRACT OF TEREDO NAVALIS

BY

EDGAR LOCKE LAZIER

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MORPHOLOGY OF THE DIGESTIVE TRACT OF TEREDO NAVALIS

BY

EDGAR LOCKE LAZIER

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INTRODUCTION

Notwithstanding the considerable volume of literature on the Teredinidae which has appeared in the past 200 years, there is to be found no comprehensive and detailed account of the digestive tract. The present paper is an attempt to describe fully the gross anatomy of the entire digestive system of one species as a foundation for future histological and physiological studies and for comparison with other forms.

The species treated is *Teredo navalis* Linn. (= *T. beachi* Bartsch, 1921) as identified by Kofoid (1921) and by Kofoid and Miller (1922). The shells and pallets of the same species have been described at some length by Miller (1922 and 1923). Specimens used for the present study were collected from various points in San Francisco Bay.

Teredo has been the subject of many writings since 1733 when Sellius published the first extensive account of it. In all these there are but few *detailed* anatomical accounts. Deshayes (1845–1848) is a striking exception, but his figures, excellent as they are, are difficult to interpret. As in most accounts, the identification of the species described is in doubt. Deshayes calls his form *Teredo navalis* Linn., but this is doubtless incorrect. Quatrefages (1849) gives a brief anatomical account of a species which he names *T. fatalis*. It is very similar to Deshayes' *Teredo*, but he differentiates the two on features of the shell, siphons, and ovary. He calls the latter species *T. deshayii*. Beuk's paper (1899) is concerned chiefly with the excretory organs, but he describes the digestive tract briefly and gives figures of it.

He deals with specimens from Trieste and also some from Naples, which he claims differ slightly, but he does not give a specific name for either form. The next important anatomical paper dealing with the digestive organs is that of Sigerfoos (1908), who studied *Xylotrya* (now *Bankia*) *gouldi* Jeffreys with occasional references to *Teredo dilatata* Spengler (= *T. sigerfoosi* Bartsch, 1922) and to *Teredo navalis* Linn. (= *T. beaufortana* Bartsch, 1922). In the account of the alimentary tract, only *Xylotrya gouldi* is discussed. The detailed anatomy of our species seems, then, to have remained undescribed. Comparison with some of the more salient points in the descriptions of the above authors will be made in this paper, but a detailed comparative account had best await further knowledge of other species.

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This study has been made possible by facilities provided by the San Francisco Bay Marine Piling Committee and is a part of their program of investigation of the marine borers of this region. I am indebted to Professor C. A. Kofoid for direction and advice throughout the progress of the work. I am also grateful to Professor C. V. Taylor for suggestions and assistance, and to Dr. R. C. Miller, associate biologist of the Piling Committee, for constant coöperation.

METHODS

Dissections were made under alcohol with the aid of a binocular dissecting microscope, and were supplemented with cross and sagittal sections. Bouin's, Zenker's, and Gilson's reagents were found to be equally satisfactory for killing and fixing. Being acid, they also decalcified the shell. A mixture of cedar oil and oil of bergamot in which was dissolved some anhydrous carbolic acid (Eycleshymer's clearing fluid) was most satisfactory for dehydrating and de-alcoholizing, following the use of 95 per cent alcohol. It was necessary to infiltrate with paraffin in partial vacuum to get good results. The sections were, as a rule, cut ten microns thick and stained with Delafield's haematoxylin. Iron haematoxylin was also satisfactory.

Ciliary currents were followed in the living animal by means of small quantities of red mercuric sulphide (vermilion pigment). This material is as fine as carmine, but much heavier, and therefore not liable to float above the cilia. Very fine carborundum dust was used as a substitute for the fine sand recommended by Kellogg (1915). It was fairly satisfactory.

MORPHOLOGY OF THE DIGESTIVE TRACT

The Teredinidae present an extreme modification of lamellibranch structure. In most of the organ systems, however, the modification is mainly of shape and position while relations and essential features remain typical. The body is greatly elongated, the visceral mass occupying approximately the anterior fourth of its length, and the gills, the remainder. The small, globular shell covers only the anterior tip of the animal; most of the organs therefore lie behind the posterior adductor muscle instead of anterior to it as in most bivalves. The kidneys, heart, and pericardium have been elongated and rotated around this muscle through an angle of 180 degrees so that their morphologically posterior end becomes anterior and their dorsal side, ventral. This places the renal orifices at the posterior end of the viscera. The other organs lie below the morphologically dorsal wall of the pericardium. The genital orifices have followed the renal orifices posteriorly. The visceral ganglion has moved from its position beneath the posterior adductor muscle to the posterior tip of the visceral mass. The cerebral and pedal ganglia and their connectives form the usual ring about the oesophagus.

The *digestive system* has not been rotated but is extended posteriorly in a long loop. The mouth and anus retain their usual positions, the former between the anterior adductor muscle and the foot, and the latter on the dorsal side of the posterior adductor. The oesophagus is the typical short, flat, ciliated tube. The stomach, however, is greatly elongated and relatively large. Its capacity is further augmented by a long, cylindrical caecum opening from its posterior end. The usual crystalline style and its mechanism are well developed, the sac of the style lying in the small, discoidal foot of the animal. The digestive glands are large and are closely applied to the stomach. The intestine is moderately long and it does not pass through either the heart or the pericardium. The anus opens into a long, anterior diverticulum of the suprabranchial cavity, the anal canal. More detailed comparison with typical lamellibranch structure will be made as the various parts of the digestive system are considered.

The *mouth* (*m.*, pl. 22, fig. 1; pl. 23, figs. 6, 7, 8; pl. 24, fig. 9), as in most bivalves, is a small, median, transverse slit. The dorsal and ventral lips are continuous, respectively, with a pair of dorsal, and a pair of ventral, *labial palps*. The dorsal palps (*d. l. p.*, pl. 24, fig. 9) are small and inconspicuous, but quite distinct, while the ventral ones (*v. l. p.*) are reduced to slightly raised, ciliated patches on the sides of the foot. The under sides of the dorsal palps are also ciliated. The labial palps of other lamellibranchs are a part of the mechanism for bringing plankton, which serves as food, to the mouth, and this function is retained in *Teredo*.

Kellogg (1915) has made a careful study of the *ciliary mechanism* for the capture and transportation of food in some thirty-six species of bivalves. No such investigation has been made for *Teredo*, but a few preliminary observations on the species we are studying indicate that a similar apparatus is present. Foreign particles touching any part of the body wall, mantle, or gills are immediately entangled in mucus secreted by the epithelium. Anything falling on the gills is quickly carried by cilia to the nearest *branchial groove* (*b. g.*, pl. 22, fig. 1). The gills extend only a little way forward on the sides of the visceral sac, but the branchial grooves continue to the labial palps (*b. g.*, pl. 22, figs. 2–5; pl. 24, figs. 9–13), and their cilia bear material rapidly forward to be taken into the mouth. This function was suggested by Sigerfoos (1908), though he was mistaken in supposing that the cilia on the mantle also assisted, as will be explained below. The cilia on the few gill bars at the anterior end of the body, the *anterior gills* (*a. g.*, pl. 24, fig. 9), beat toward the groove. Unlike the more generalized lamellibranchs, cilia do not cover the visceral sac and the interior of the mantle, but are restricted to a narrow strip on the mantle opposite the branchial groove (*ci.*, pl. 22, figs. 2–5; pl. 24, figs. 10–13). Here, particles entangled in mucus are borne rapidly toward the posterior end of the infrabranchial cavity. If the branchial groove is carrying forward more than a very small amount of material it is, without doubt, caught away and carried back by these cilia. Here we have a mechanism which determines on the basis of quantity, and not of quality, whether or not matter taken from the water shall reach the mouth. This is in accord with Kellogg's findings in all the forms he studied, and is a clue to the analysis of the rôle of turbidity in the ecology of this borer.

The palps of this species of *Teredo* are so reduced that it is doubtful if they exercise much, if any, control over the stream of plankton and other material from the water. Particles falling on the non-ciliated surface of the mantle or body are drawn into a ciliary current by the strands of mucus that are secreted. Material that is carried posteriorly by the cilia on the mantle is expelled from the pallial cavity. The writer has seen a *Teredo,* which had been removed from the wood and was siphoning in a dish of water, collect excess sediment in the posterior part of the infrabranchial cavity and suddenly eject it through the in-current siphon, apparently by a quick contraction of the mantle. This corresponds to the action of mollusks with a closed mantle as described by Kellogg (1915), except that there the adductor muscles effect the contraction. There are cilia on the sides of the foot which carry particles upward to the labial palps. These ciliated tracts doubtless serve to collect wood fibers rasped off in boring. The details of the ciliary mechanism of *Teredo* remain to be worked out, but it is apparent that there exists an apparatus similar to that of other lamellibranchs for the capture and transportation of plankton.

Sigerfoos (1908) does not mention the labial palps. Deshayes (1845–1848) and Quatrefages (1849) both figure four long, narrow ones. It is evident that these structures will prove to be of value in systematic distinctions, at least for some species.

The *oesophagus* (*oe.*, pl. 22, fig. 1; pl. 23, fig. 6) resembles that of most lamellibranchs. It is short, dorso-ventrally compressed, and heavily ciliated throughout its length. It narrows posteriorly so that its width at the stomach is about one-half that at the mouth. In the walls are several longitudinal furrows.

The *stomach* (pl. 22, fig. 1; pl. 23, figs. 6, 7, 8) is long and subcylindrical. Most of the digestive glands lie on the right side of the visceral mass so that the stomach lies somewhat to the left. Its anterior end (*a. st.*) is broadened toward the right and the posterior one (*p. st.*) is somewhat dilated.

The stomach is always found nearly empty of food. Serial sections show a great deal of coagulated, lightly staining, digestive juices with a small amount of wood fibers and plankton. This can be seen in plate 24, figures 10 and 11. The other parts of the alimentary canal are usually full of plankton and wood chips, indicating that the passage of food through the stomach is relatively rapid.

The *digestive glands,* or *livers,* which, primitively, are paired evaginations of the walls of the stomach (Pelseneer, 1906; Sigerfoos, 1908), are broken up into a number of glandular masses in *Teredo,* each emptying into the stomach by one or more orifices. The glands are closely applied to the walls of the stomach so that no exposed ducts are present. Food material enters the proximal lumina of at least some of the ducts (pl. 24, fig. 11). For convenience we have designated anterior, ventral, and posterior livers. None of these, except the posterior one, is a single mass.

In the pedal region there is a considerable amount of digestive gland, the anterior liver (*a. l.*, pl. 22, fig. 1; pl. 23, figs. 6, 7, 8). This communicates with the stomach by several orifices of varying sizes in the right wall (*a. st.*, pl. 22, fig. 1) and by one in the left wall. The latter orifice is in the anterior wall of the lateral pouch (*l. p.*, pl. 23, figs. 6, 7).

The ventral livers (*v. l.*, pl. 22, fig. 1; pl. 23, figs. 6, 7, 8) are small and communicate with the stomach by four small orifices (*v. h. o.*, fig. 1).

The *posterior liver* (*p. l.*, pl. 22, figs. 1–4; pl. 23, figs. 7, 8; pl. 24, figs. 10, 11, 12) is a large gland lying on the right side of the stomach at its posterior end. Its large duct opens to the stomach by a very large circular orifice (*p. h. o.*, pl. 22, figs. 1, 3; pl. 24, fig. 11). Deshayes (1845–1848) describes many hepatic orifices in this region instead of the single large one found here in Sigerfoos' (1908) species. Although the posterior liver is externally a unit, it is divided into two parts differing histologically. The cells composing the dorsal part are columnar, making the walls of the acini thick, while the cells of the ventral part are hardly higher than the diameter of their nuclei. This differentiation is indicated diagramatically in plate 22, figures 3 and 4, and the external appearance is shown in plate 23, figure 8. The difference in the appearance of the tissues is quite marked in the photomicrograph, plate 24, figure 12. Sigerfoos (1908) describes this same condition in the species he studied. It will be noted that the presumably different secretions of the two parts must mix even before they reach the stomach, which suggests numerous physiological possibilities. The anterior and ventral livers exhibit no such differentiation.

Besides the livers, the stomach bears four other diverticula: the caecum, the sac of the crystalline style, the dorsal caecum, and the lateral pouch. The most conspicuous is the large posterior *caecum* (*c.*, pl. 22, figs. 1, 5; pl. 23, figs. 6, 7, 8; pl. 24, fig. 13). This equals or exceeds the stomach in capacity. It is cylindrical in shape, but the ventral wall is infolded to form an elaborate, two-coiled typhlosole (*c. t.*) extending its entire length. This caecum is always found full of wood chips, and it is here, presumably, that wood is digested. Only rarely have evidences of plankton been found in it, though they are common in the intestine. The great capacity of the caecum allows the wood, which is probably slow to digest, to remain there for some time. The typhlosole affords a large area for absorption and has an adequate blood supply. A large artery carries aerated blood directly from the heart to the anterior end of the caecal typhlosole. The term *caecal artery* seems appropriate for this vessel (*c. a.*, pl. 22, figs. 1, 4; pl. 24, fig. 12). After passing through the typhlosole the blood flows into the sinuses in that part of the body.

Sigerfoos (1908) states that the interior of the caecum in the species he studied is ciliated. None of the present writer's preparations show any cilia whatever in the caecum, nor are the cells of the tall, columnar variety which usually bears cilia. The caecum of a living animal, just removed from the wood, was opened and the contents washed out with a pipette. Small quantities of mercuric sulphide and of fine carborundum dust were placed on various parts of the wall and on the typhlosole. There was no indication of any ciliary action, though such activity was very evident in other parts of the stomach and in the pallial cavity under like conditions. Slow writhing movements of the typhlosole were observed, however, and it is apparent that material is moved in and out of the caecum by muscular movements of the walls rather than by cilia. The experiment was repeated on several animals with similar results. This muscular movement approaching peristalsis is an unusual development in this order of lamellibranchs.

The orifice between the caecum and the stomach (*c. o.*, pl. 22, figs. 1, 4; pl. 23, figs. 6, 7; pl. 24, fig. 12) is incompletely divided into two openings by two lateral infoldings of the wall. The right fold is continuous with the caecal typhlosole. This arrangement probably provides for simultaneous ingress and egress of wood chips through the two divisions thus formed. The musculature of this orifice has not been worked out.

Deshayes (1845–1848) and Quatrefages (1849) describe a caecum strikingly different from that described here and by other authors. Deshayes calls it the *second stomach.* It is thin walled, with a narrow orifice, and with a typhlosole (*"valvule"*) like a funnel. This second stomach doubles back on itself and ends blindly. It is buried in brown hepatic tissue. The intestine takes off from it. Quatrefages goes into less detail in describing his species but his figures indicate essentially the same structure. He denies, however, that the intestine leaves the caecum and believes this statement to be an error on the part of Deshayes.

The *sac of the crystalline style* (= *caecum*, Nelson, 1918) (*s. c. s.*, pl. 22, fig. 1; pl. 23, figs. 6, 7, 8) lies in a transverse position in the lower part of the foot, opening into the stomach on the left. The whole mechanism of the crystalline style is essentially similar to that described by Nelson (1918) for other lamellibranchs. The sac is pyriform and the interior is covered with the characteristic dense mat of long cilia. Extending from the mouth of the sac to its distal end is a small groove in the wall with a slight ridge on one side of it. The cells along this groove and ridge differ from those of the rest of the sac in that they stain deeply with Delafield's haematoxylin, are narrower, bear shorter cilia or none at all, and have their nuclei close to the basement membrane instead of near the center or toward the distal ends. From Nelson's description of other species, we conclude that these cells are the ones which secrete the substance of the crystalline style. This groove terminates distally in the orifice of a small appendix to the sac (pl. 22, fig. 1). This appendix (*ap.*, pl. 23, fig. 8) is termed by Sigerfoos (1908) the tubular part of the sheath of the crystalline style. Its thin walls are made up of non-ciliated cells similar to those in the secretory groove and ridge and are continuous with them, indicating that it contributes to the formation of the style, as Sigerfoos suggests. A large fold of epithelium overhangs the opening of the sac into the stomach (pl. 23, fig. 6).

The *crystalline style* itself is of the usual clear, gelatinous substance. It is shaped like a heavy club, the smaller, or "handle," end of the club projecting across the lumen of the stomach to the opposite wall where it bears against the structure which Nelson (1918) terms the *gastric shield* (*g. s.*, pl. 22, fig. 1; pl. 23, fig. 6). This shield is a thin, transparent, cartilage-like plate secreted by the epithelium of the stomach. It may be dissected out or may be seen in microscopic sections. Its posterior and dorsal edges are marked by a faint ridge on the wall of the stomach. Ventrally it extends to the mouth of the sac of the style, and anteriorly it reaches into the lateral pouch and the dorsal caecum (*d. c.*, pl. 23, fig. 6).

Deshayes (1845–1848) does not mention the crystalline style nor the gastric shield. Quatrefages (1849), however, describes the style as lying in the foot. He believes that the second branch, or blind end, of the "*siphon*" of the first stomach in Deshayes' description is the sac of the crystalline style. This is probably correct as it corresponds almost exactly in position and arrangement with that organ in the species we are studying. Quatrefages describes also a cartilaginous structure on the wall of the stomach which is probably the "flèche tricuspide" of other French authors, or what we now call the gastric shield. Beuk (1899) figures, but does not mention, a long narrow sac for the style opening to the stomach near the caecal orifice. Sigerfoos' (1908) very brief description of the crystalline style and its attendant structures agrees with the present observations, though he does not mention the gastric shield. Barrois (1889–1890) in his classic paper on the crystalline style does not mention *Teredo.*

Nelson (1918) reviews all previous investigations of this peculiar molluscan structure and contributes much original material. His conclusions as to its structure and function seem to end a long controversy. The observations we have recorded here agree in all essentials with his descriptions of species in which the sac is entirely separated from the intestine. He did not examine any *Teredo* and makes only one or two references to their style. He mentions a style of similar shape, but of much greater proportions, in two other borers. *Pholas,* and *Martesia.*

Nelson (1918) found that the style is slowly rotated by the cilia lining its sac and that it is gradually dissolved away. It thus helps to keep in motion the contents of the stomach, and the amylolitic ferments which it contains are set free to aid in digestion. The style in *Teredo* doubtless functions in a similar manner.

In *Teredo navalis* the crystalline style seems small in proportion to the stomach, as compared with such forms as *Martesia. Mya,* and *Donax.* This suggests that it is concerned only with the digestion of plankton and that the ingested wood is cared for by other means.

From the left antero-dorsal wall of the stomach projects a small, pointed diverticulum, the *dorsal caecum* (*d. c.*, pl. 23, figs. 6, 7). This is called the secondary caecum by Sigerfoos (1908), but it is probably homologous with what Gutheil (1912) calls "Magenfalte" of *Anodonta.* Nelson (1918) refers to this as the dorsal caecum and this seems to be the most appropriate term. This caecum is ciliated internally.

Between the dorsal caecum and the orifice of the sac of the crystalline style is a distinct outpocketing of the wall, which we have referred to as the *lateral pouch* (*l. p.*, pl. 23, figs. 6, 7). It is overhung by a peculiar roll of epithelium.

In lamellibranchs there is typically a typhlosole in the intestine, extending more or less throughout its length, and, as a rule, anteriorly into the stomach. In *Teredo navalis* this typhlosole, which we shall call the *gastro-intestinal typhlosole* (*g. i. t.*), originates at the hepatic orifice in the lateral pouch (pl. 23, fig. 6), passes across the stomach below the opening of the oesophagus and posteriorly along the right ventral wall to the posterior hepatic orifice which it enters (pl. 22, figs. 1, 2, 3). After circling the lumen of the posterior liver, it emerges at the dorsal edge of the orifice and passes posteriorly and ventrally into the intestine. Its fate there will be described in connection with the latter organ. From the hepatic orifice to the intestine, a small ridge lies opposite the free edge of this typhlosole. The gastro-intestinal typhlosole is ciliated throughout its entire length.

A second fold, which we may call the *gastric typhlosole* (*g. t.*), originates in the dorsal caecum (pl. 23, figs. 6, 7), passes above the opening of the oesophagus, and, running parallel to the previously described typhlosole, extends to the posterior hepatic orifice where it ends (pl. 22, figs. 1, 2). A low, ciliated ridge (*c. r.*) parallels its free edge and continues on above the hepatic orifice and down to end beneath the right one of the two folds lying in the caecal orifice (pl. 23, fig. 6).

Between this ridge and the one accompanying the gastro-intestinal typhlosole is a row of small, transverse folds in the wall of the stomach (pl. 22, fig. 1). They extend from the posterior end of the gastric typhlosole to the fold under which the ciliated ridge ends. From the other (left) fold in the caecal orifice, around to the right fold, in a spiral course, is another row of more pronounced wrinkles and pockets (pl. 22, fig. 1; pl. 23, fig. 6). The appearance of these on the outside of the stomach is shown in plate 23, figure 7. The function of these two rows of irregular corrugations, which are of practically constant occurrence, is probably to increase the surface or the capacity of the stomach.

There is a small ridge, or lip, above and below the opening of the oesophagus into the stomach. The ventral one extends some distance to the left between the dorsal caecum and the lateral pouch.

Cilia do not cover the whole interior of the stomach as in more generalized bivalves, but are restricted to definite regions. The ciliated ridge and the gastro-intestinal typhlosole have been mentioned as being ciliated, but the ciliary mechanism of the alimentary tract has not yet been fully worked out in *Teredo* as it has by Nelson (1918) in several other forms. A few observations on living animals, however, have shown strong, localized, ciliary currents, and further investigation will probably disclose an elaborate mechanism for handling and sorting food homologous with that found in other species. The method of manipulating the wood chips which are ingested would of itself be an interesting discovery.

The *intestine* (*i.*), from its origin at the stomach (*p.*, pl. 22, figs. 1, 3; pl. 23, figs. 6, 7; pl. 24, fig. 11), runs anteriorly a short distance and bends sharply upon itself. Its course is then back, remaining ventral, to the posterior end of the caecum, up around the latter and forward through the gonad, passing to the left of the caecal artery (*c. a.*) and posterior aorta (*p. ao.*). It goes under the posterior adductor muscle, bending a little to the left and then back to the mid-line, and ends on the dorsal side of this muscle in the anal canal. The intestine is not as straight as it is shown in the stereogram, but it makes no extensive convolutions or bends other than those indicated.

The gastro-intestinal typhlosole enlarges in the intestine, a short distance from the stomach, and coils to the right, forming the large *coiled typhlosole of the intestine* (*c. t. i.*, pl. 22, figs. 1, 2; pl. 23, figs. 7, 8; pl. 24, fig. 10). It then again resumes its former size and continues to the sharp bend in the intestine. From here to the anus the typhlosole is entirely absent. Plate 23, figure 8, shows the dilation of the intestine to two or three times its diameter elsewhere for the accommodation of this unique structure. In this same figure can be seen the line where the intestinal wall folds in to form the typhlosole. At the distal end of the rectum are a few strands of sphincter muscle. The intestine is ciliated throughout.

Sigerfoos (1908) gives a similar description, but in his species a small typhlosole extends throughout the whole intestine. Deshayes (1845–1848) and Quatrefages (1849) describe the intestine as being of uniform diameter throughout, indicating the absence of a coiled typhlosole. At the same time the intestine is longer and much convoluted, though its general course through the body is similar. These two distinct types of intestine are easily observed and should prove of systematic value. The consideration of such internal characters may shed some light on the badly tangled taxonomy of the group.

The intestine is always found to be full of wood chips and the remains of diatoms and other plankton. In a piece of intestine removed from a small living *Teredo*, the contents were observed to move posteriorly about one millimeter in two minutes as the result of ciliary action.

The circulation of blood in the various parts of the digestive tract is still to be worked out in detail, but one of two major points may be mentioned. The whole tract, including the livers, is evidently bathed in blood carried in sinuses with connective tissue walls (Pelseneer, 1906). The typhlosoles, however, have a definite arterial supply. That of the caecal typhlosole has been described above. A small branch from the posterior aorta (pl. 22, fig. 1) supplies the gastro-intestinal typhlosole at the bend of the intestine where the typhlosole ends. Another small branch (*ar.*, pl. 24, fig. 11) goes to the dorsal edge of the posterior hepatic orifice, probably supplying the gastric typhlosole.

THE DIGESTION OF WOOD

The extent to which Teredo digests wood and the conditions under which this digestion proceeds have an important bearing on the success or failure of methods of wood preservation, aside from their purely biological interest. Physiological and chemical evidence that wood is digested to a considerable extent has been accumulated (Harrington, 1921; Dore and Miller, 1923). The caecum with its large typhlosole has generally been accepted as good evidence for the digestion of wood, and the fact that a third or more of the blood leaving the heart is led directly through this typhlosole makes it certain that we have here a very effective organ of absorption.

Evidence of the digestion of cellulose was found in the serial sections that were prepared during the course of the present investigation. The contents of the stomach, caecum, and intestine usually remained in place in the sections. This can be seen in the photomicrographs on plate 24. When sections were stained with Delafield's haematoxylin, the wood fibers in the stomach and in the caecum took the stain, while those in the intestine did not to any appreciable degree. Since Delafield's is a selective stain for cellulose (Molisch, 1921), it is evident that at least a part of the cellulose had been removed from the wood fibers during their stay in the stomach and caecum. Unfortunately the difference in color does not show in the photomicrographs.

SUMMARY

1. The digestive tract of *Teredo navalis* Linn. is well developed, and although highly specialized, it retains the essential features of the typical lamellibranch system.

2. The dorsal labial palps are small but distinct; the ventral pair are reduced but still functional.

3. The usual ciliary mechanism for the capture and ingestion of plankton and for the disposal of excess sediment taken from the water is present in a slightly modified form, with additional ciliated tracts for the ingestion of the wood fibers obtained by boring.

4. The stomach is long and subcylindrical.

5. The digestive glands are highly developed. The posterior one communicates with the stomach by a single orifice, but consists of two kinds of secretory tissue.

6. The large caecum characteristic of the Teredinidae is present. A large artery carries blood directly from the heart to the caecal typhlosole. The interior of the caecum is not ciliated, but food is apparently moved by muscular activity.

7. The crystalline style and its related mechanism are similar to that of many other lamellibranchs.

8. A small, pointed dorsal caecum is present.

9. The stomach contains two typhlosoles, one of which is continuous with that of the intestine.

10. The cilia in the stomach are confined to certain limited tracts.

11. The intestine is relatively short and contains a large coiled typhlosole near the stomach. Throughout the remainder of its length the typhlosole is absent.

12. The whole digestive tract is bathed in blood carried in sinuses. The typhlosoles have a direct arterial supply.

13. Comparisons with descriptions by other authors indicate wide differences in the gross structure of the alimentary tract in various species of Teredinidae. Such differences may prove of taxonomic value.

14. Differential staining of wood fibers in the caecum and in the intestine is evident of the digestion of cellulose.

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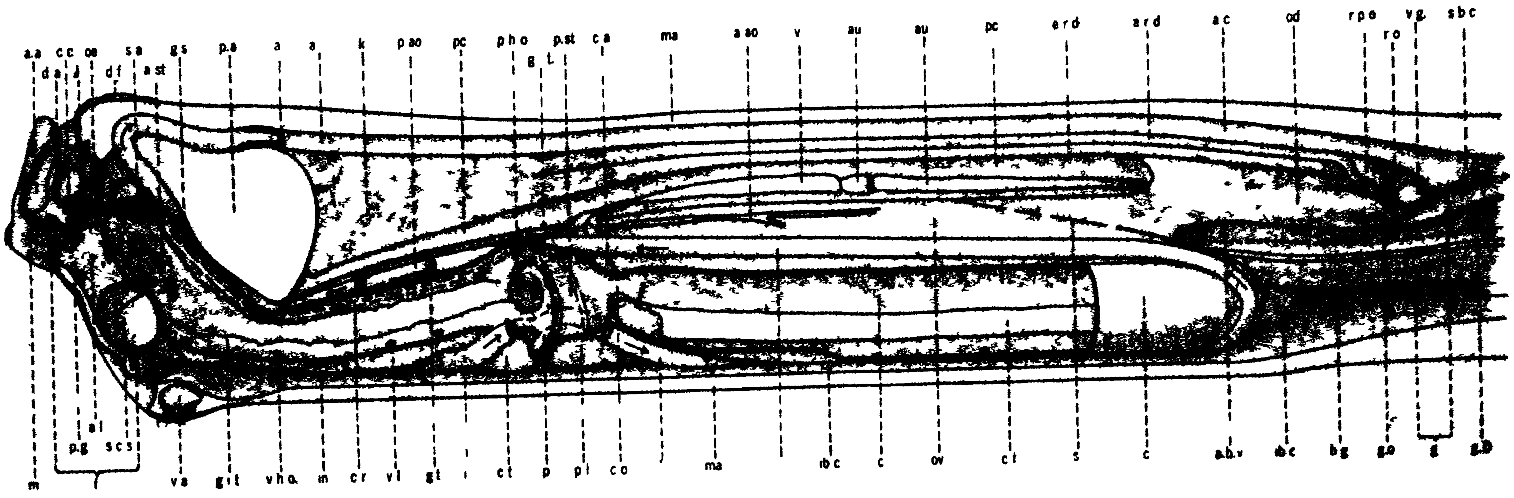
EXPLANATION OF PLATES

PLATES 21 AND 22

Fig. 1. Stereogram of *Teredo navalis,* anterior part, including the visceral mass, nearly all of the left half of the body having been removed to disclose structures lying in or near the sagittal plane. The anterior end of the animal is to the reader's left. The left half of the stomach, removed in this figure, is shown in plate 23, figure 6. Animals killed in alcohol have the foot completely retracted and all the drawings have been made with it in this condition. *Figure 1 and figures 6 to 9 are stereograms and all are drawn to the same magnification, about 7 diameters.*

Figs. 2–5. Diagramatic cross-sections at the levels indicated on figure 1. Anterior aspect.

a.	Anus.
a.a.	Anterior adductor muscle of the valves.
a.ao.	Anterior aorta, homologous with the anterior aorta of other lamellibranchs, though running posteriorly in *Teredo.*
a.b.v.	Afferent branchial vein, paired anteriorly, but single in the region of the gills.
a.c.	Anal canal, a forward extension of the suprabranchial cavity.
a.l.	Anterior liver.
a.r.d.	Afferent renal duct (paired).
a.st.	Anterior part of stomach.
au.	Auricle of the heart. The left one is shown cut off close to the ventricle.
b.g.	Branchial groove. One lies along each ventral edge of the gills, continuing forward on the side of the body to the labial palps.
c.	Caecum of the stomach. In figure 1 the left wall is removed, except from the posterior fourth.
c.a.	Caecal artery.
c.c.	Cerebral commissure, connecting the cerebral ganglia, which are widely separated.
ci.	Ciliated strip on the mantle.
c.o.	Caecal orifice.
c.r.	Ciliated ridge.
c.t.	Caecal typhlosole.
c.t.i.	Coiled typhlosole of the intestine.
d.a.	Dorsal articulation, or pivotal knob, of the shell.
d.D.	Duct of the gland of Deshayes.
d.f.	Dorsal pallial fold.
e.r.d.	Efferent renal duct (paired).
f.	Foot.
g.	Gill.
g.D.	Gland of Deshayes in the gill lamellae. (Discovered and named by Sigerfoos, 1908.)
g.i.t.	Gastro-intestinal typhlosole.
g.o.	Right genital orifice.
g.s.	Gastric shield. Only a small part of the right edge shows in figure 1.
g.t.	Gastric typhlosole.
i.	Intestine. The arrows point toward the anus.
ib.c.	Infrabranchial cavity. The arrow indicates the direction of the flow of water.
in.	Integument of the visceral mass.
k.	Kidney, the tubular, spongy part of the excretory system.
l.	Ligament of the shell.
l.c.	Lateral canal. These are later, anterior extensions of the suprabranchial cavity, communicating with the infrabranchial cavity through the anterior gills (see pl. 24, fig. 9).
m.	Mouth.
ma.	Mantle.
od.	Right oviduct.
oe.	Oesophagus.
ov.	Ovary. In male specimens the testes are similar in extent and relations (see pl. 24, figs. 11-13).
p.	Pylorus.
p.a.	Posterior adductor muscle of the valves.
p.ao.	Posterior aorta, homologous with the posterior aorta of other lamellibranchs, though running anteriorly in *Teredo.*
p.ar.	Pallial artery, a continuation of the posterior aorta after it has looped over the posterior adductor muscle.
pc.	Pericardium. Posteriorly it bifurcates, one auricle of the heart extending into each ramus and one afferent renal duct opening from each.
p.g.	Pedal ganglia. The two are fused.
p.h.o.	Posterior hepatic orifice.
p.l.	Posterior liver.
p.st.	Posterior, pyloric region of the stomach.
r.o.	Right renal orifice.
r.p.o.	Right reno-pericardial orifice.
s.	Septum, separating regions that are probably homologous with the pedal and venous sinuses.
s.a.	Supraoesophageal artery, a branch of the posterior aorta.
sb.c.	Suprabranchial cavity. The arrow indicates the direction of the flow of water.
s.c.s.	Sac of the crystalline style. Figure 1 shows the distal end from the inside.
st.	Stomach.
v.	Ventricle of the heart. The arrows at its anterior end indicate the direction of the flow of blood.
v.a.	Ventral articulation, or pivotal knob, of the shell.
v.g.	Visceral ganglia.
v.h.o.	Ventral hepatic orifice. There are four of these, as shown in figure 1.
v.l.	Ventral liver.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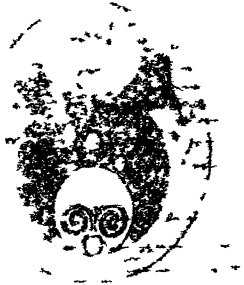

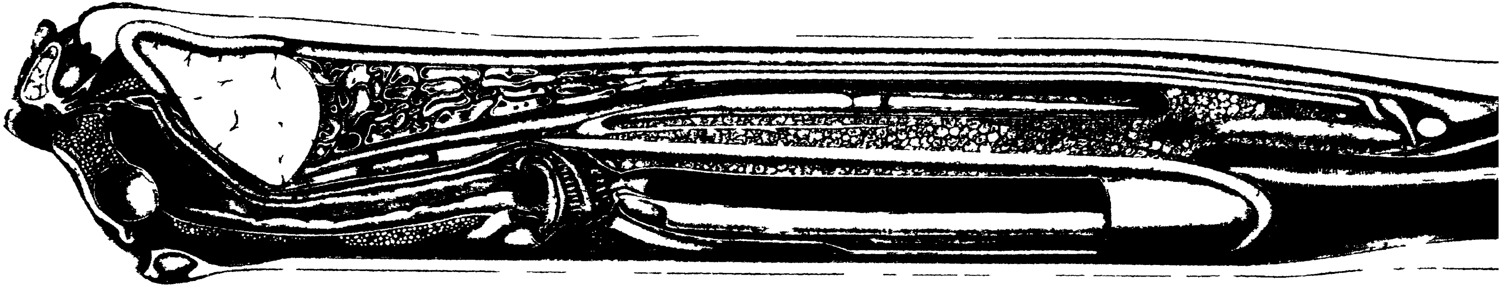

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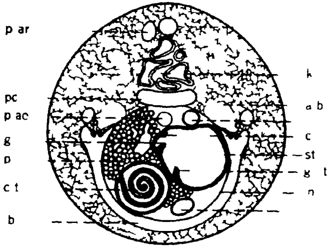
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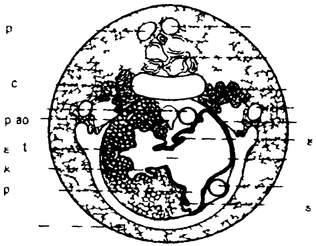
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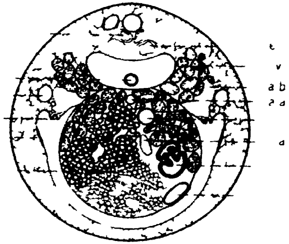
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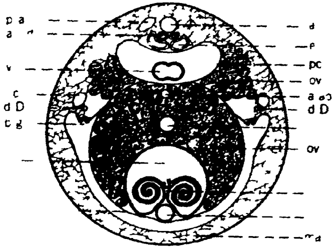
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PLATE 23

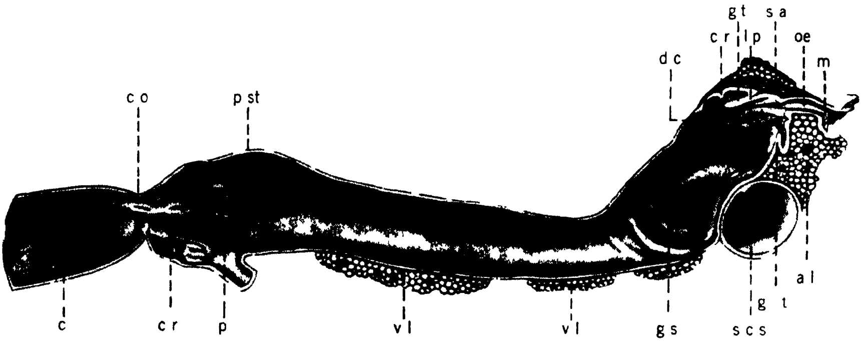
Teredo navalis L.

Fig. 6. Interior of the left half of the stomach, the part not shown in plate 22, figure 1. The arrow passes through the orifice of the sac of the crystalline style to the gastric shield.

Fig. 7. Lateral, external view of the stomach from the left.

Fig. 8. Lateral, external view of the stomach from the right.

a.l.	Anterior liver.
ap.	Appendix of the sac of the crystalline style.
c.	Caecum.
c.o.	Caecal orifice.
c.r.	Ciliated ridge.
c.t.i.	Region of the coiled typhlosole of the intestine.
d.c.	Dorsal caecum.
g.i.t.	Gastro-intestinal typhlosole.
g.s.	Gastric shield.
g.t.	Gastric typhlosole.
i.	Intestine.
l.p.	Lateral pouch.
m.	Mouth.
oe.	Oesophagus.
p.	Pylorus.
p.l.	Posterior liver.
p.st.	Posterior, pyloric region of the stomach.
s.a.	Supraoesophageal artery.
s.c.s.	Sac of the crystalline style.
v.l.	Ventral liver.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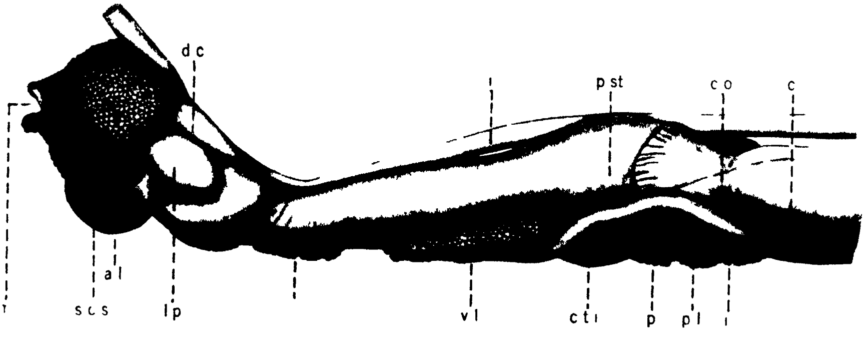
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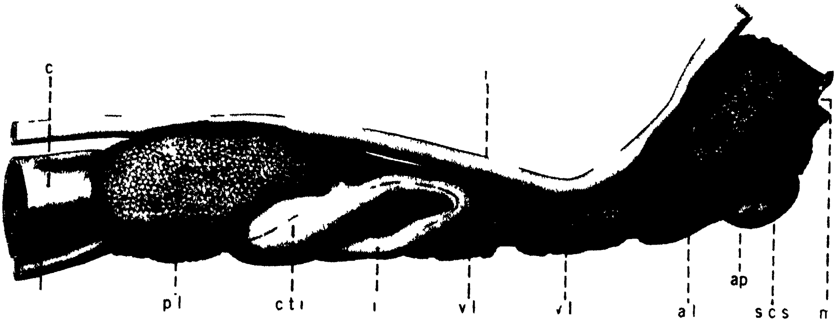
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PLATE 24

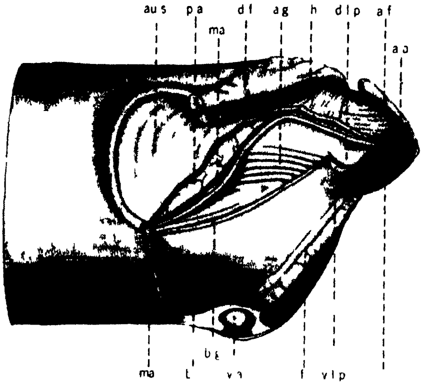
Teredo navalis L.

Fig. 9. External view of the anterior end of the body from the right. Part of the right valve and mantle have been dissected away.

Figs. 10-13. Photomicrographs of cross-sections of a small male specimen, anterior aspect. These four figures correspond, respectively to figures 2, 3, 4, and 5 on plate 22. Since the photomicrographs are of a smaller animal than that represented by the diagrams, the acini of the liver and the lobules of the gonad are relatively larger in the former. *Magnification 25 diameters.*

The specimen from which these sections were made was taken from a pile at Crockett, San Francisco Bay, on July 6, 1922. It was fixed in Gilson's fluid, imbedded in parafin, the sections cut 10 microns thick, and stained in Delafield's haematoxylin.

a.a.	Anterior adductor muscle.
a.ao.	Anterior aorta.
a.b.v.	Afferent branchial vein.
a.c.	Anal canal
a.f.	Anterior pallial fold.
a.g.	Anterior gills
ar.	Artery to dorsal edge of hepatic orifice. Also indicated on plate 22, figure 3.
a.r.d.	Afferent renal duct.
au.s.	Auricle of the shell.
b.g.	Branchial groove.
c.	Caecum.
c.a.	Caecal artery.
ci.	Ciliated strip on mantle.
c.o.	Caecal orifice.
c.r.	Ciliated ridge.
c.t.	Caecal typhlosole.
c.t.i.	Coiled typhlosole of the intestine.
d.D.	Duct of the gland of Deshayes
d.f.	Dorsal pallial fold.
d.l.p.	Dorsal, or external, labial palp.
e.r.d.	Efferent renal duct.
f.	Foot.
g.i.t.	Gastro-intestinal typhlosole.
g.t.	Gastric typhlosole.
i.	Intestine
ib.c.	Infrabranchial cavity.
in.	Integument of the visceral mass.
k.	Kidney
l.c.	Lateral canal.
m.	Mouth.
ma.	Mantle.
p.	Pylorus
p.a.	Posterior adductor muscle.
p.ao.	Posterior aorta.
p.ar.	Pallial artery.
pc.	Pericardium
p.h.o.	Posterior hepatic orifice.
p.l.	Posterior liver.
s.	Septum.
sh.	Shell.
t.	Testes
v.	Ventricle.
v.a.	Ventral articulation of the shell.
v.l.p.	Ventral, or internal, labial palp.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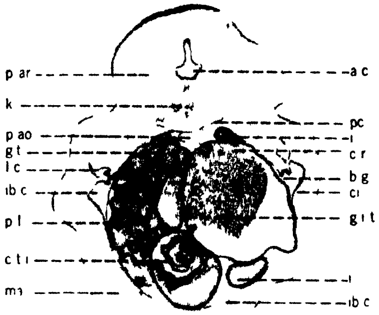
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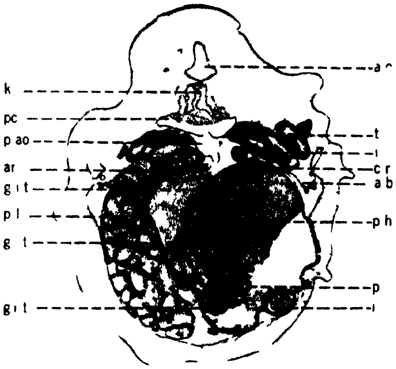
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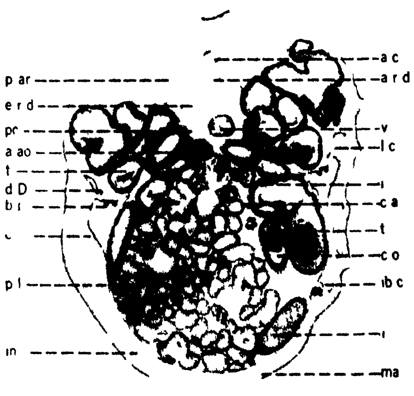
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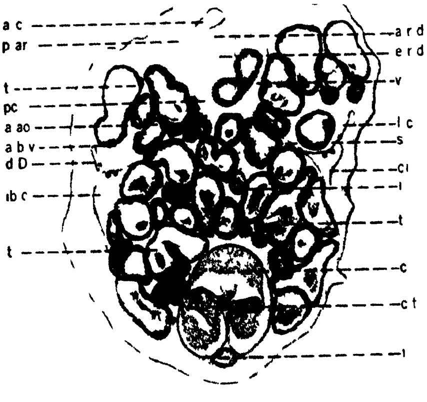
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* Univ. Calif. Publ. Zool., vol. 22. There are two pages numbered 445. References to these pages are given as 445*a* and 445*b*, respectively.

Titles of papers and names of new species are printed in bold face.

With respect to citations, this rule is followed: If the reference is included in the "Literature Cited" at the end of the paper, the author's name is not separately entered in the index.

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